in brief

COVER BY SAM HALTOM

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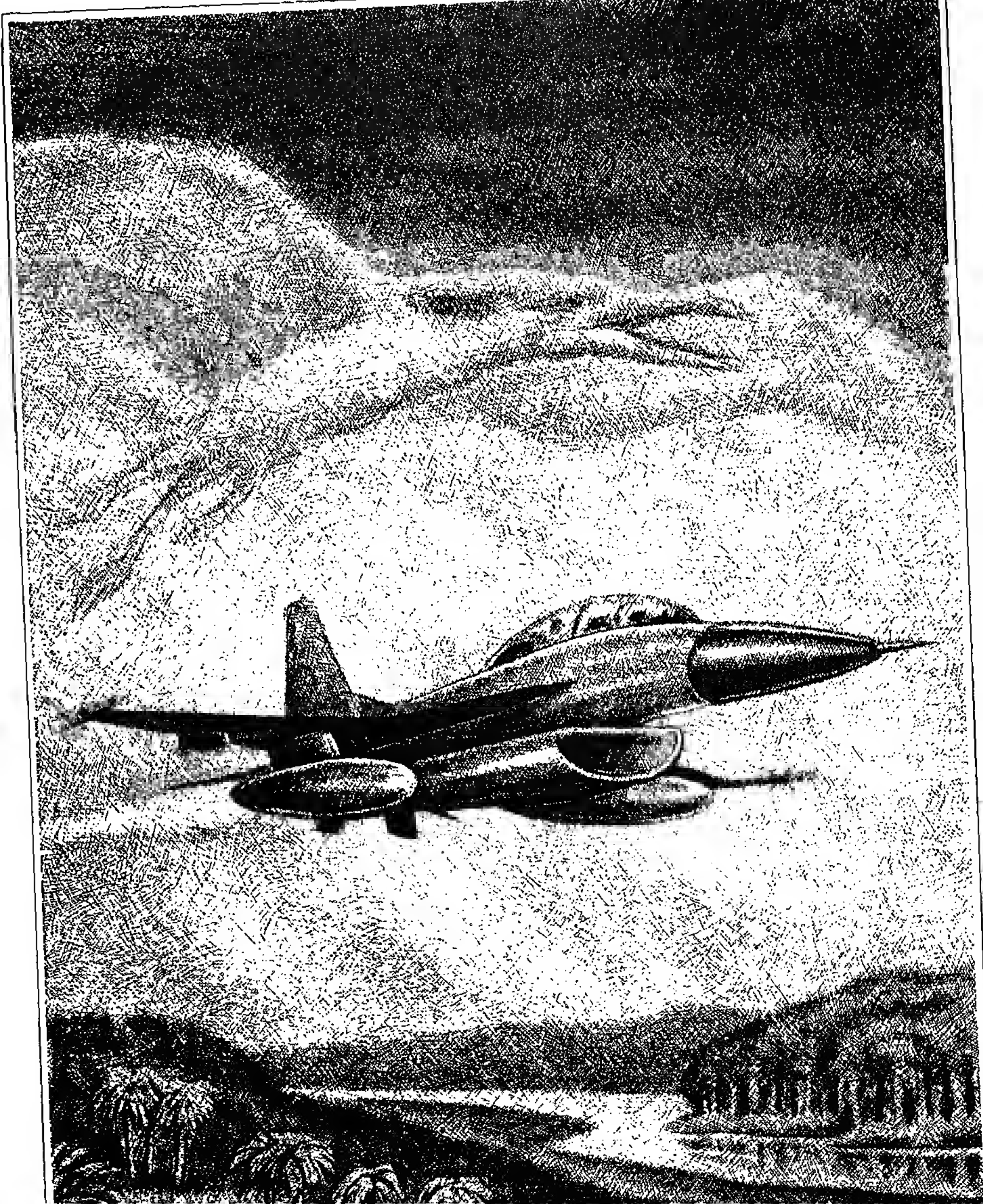

Establishing supportability a critical requirements factor

By GENERAL JAMES P. MULLINS, USAF

uirements process not geared to supportability considerations he most pressing problem confronting Air Force acquisition and logistics managers today.

; than *160 million years,* voracious reptiles linosaurs ruled the earth. They filled every iche; they crawled, they swam, they flew, . Then, some 60 million years ago, these ters of the earth suddenly vanished. Many lieve a cosmic catastrophe sprayed the earth on and destroyed the ozone layer, which in ved the organisms that were staples in the t.

ately, there are some disturbing similarities dinosaur of yesterday and the Air Force of those great reptiles, we've been character- e time now by great strength and relative in- . We've derived our power from tech- like the dinosaur, we are beginning to find it deal with the new realities of life around created by the very technology that gave us in the first place. Indeed, like the dinosaur, selves roaming stubbornly down the well- of outdated mind-sets, oblivious to the our environment and the serious conse- t are likely to result.

envlronment unquestionably has changed: versaries are stronger, and the vital staples ise industry are vulnerable. As a result, our dapt to and cope with the threat is itself eatened.

d of World War II, this country enjoyed the protection of being separated from our two great oceans. Our industrial might was one, and there was virtually no resource we trol. But technology has changed all that. been so reliant on the capability provided by modern military technology; and yet, we've never been so vulnerable to the destructive power it can generate. Indeed, we've reached the point at which almost any nation can obtain the wherewithal to threaten substantially the vital interests of even major military powers, as events last year in the South Atlantic so clearly demonstrated.

Thus, we must rely more than ever before on our weapon systems having real, sustalnable combat capability—and having it whenever and wherever it may be needed. But perhaps like the dinosaurs' inability to comprehend the consequences of a cosmic radiation bombardment, our lack of focus on the logistics required to make these weapon systems truly effective may ultimately clear the path to our own destruction.

Because of the way our system works today, we've become predisposed to buy so-called "rubber on the ramp," or the highest performance capability we can get. Until recently, we've given precious little thought to the funding and procurement of logistics support items. Just consider the ongoing shortfalls in exchangeable spares for the F-15. What we're doing makes as much sense as buying an expensive portable radio with just one set of batteries and no plans to replace them when they wear out.

For years we've traded off real combat capability for the illusion of capability—an illusion of total numbers in an inventory, not of sorties that can be flown or ordnance that can be delivered. In the past we purchased, say, 100 new airplanes but very few spares. Typically these systems have promised an operational readiness rate of about 75 percent; just as typically, this rate has dropped off almost immediately because of spares

peacetime operational and training requirements.

Two primary solutions to the problem come immediately to mind. We can either build systems that are reliable and durable enough to obviate the need for additional logistics support, or we can act to insure that when we buy new weapon systems, we also secure the logistics support they must have.

Obviously, building systems that are so durable that maintenance and spares are unnecessary is a long-term goal. We believe it is theoretically achievable over time, but not, in its entirety, in the forseeable future.

The short-term alternative, on the other hand, seems simple enough. For the same dollars, we could purchase 90 airplanes instead of 100 and use the remaining funds to buy as much increased reliability as technology could provide; to the extent that such reliability was unachievable, we could use the money to procure adequate spares and piece parts. We could thus have perhaps 90 percent of 90 airplanes, or 81 combat-ready systems, instead of 50 of 100.

To do this, though, we must first examine our requirements process to determine just why we don't have a better balance between the acquisition of systems and essential logistics support. The problem stems in part from the profit motive that drives our free-enterprise defense industry. I'm certainly not saying profit is bad; to the contrary, it is our economy's great strength. Profit has been the underpinning for many of the great achievements in American history. But the profit motive undeniably affects our requirements process by pandering to our infatuation with bigger and better weapon systems at the expense of the spares and piece parts that these systems must have to be effective in time of war.

In order to meet design lead times for development programs, the prime contractor will have already begun independent research and development.

The initial IR&D involves an evaluation of current and future technology as well as a preliminary assessment of the operational environment and attendant service needs. In effect, it represents the preconceptual phase of weapon system development and is heavily dependent on the existing technology base. System design actually begins in this phase. Only after this step are designs refined in conceptual and demonstration phases and ultimately completed prior to critical design review and full-scale development.

Usually the prime contractor won't even begin discussions with the Air Force until he has completed his preconceptual IR&D assessment. In fact, it's not until the demonstration-validation phase that a program office and a deputy manager for logistics are assigned; consequently, it isn't until then that this manager, the prime contractor, and the system project officer actually gather to design, plan, and implement a support strategy.

Under the current arrangement, then, the contractor validates the results of his independent research through marketing briefings to the using commands; when such briefings lead to a contract award, the contractor has, in effect, created a requirement. In reality, weapons capabilities influence military requirements, and prime contractors develop weapons capabilities.

From both a logistics and a combat capability viewpoint, this process presents a serious problem for several reasons. First, system design clearly precedes support design; consequently, support strategies are generally

> *We've never been so reliant on the capability provided by modern military technology; and yet, we've never been so vulnerable to the destructive power it can generate.*

To be blunt about it, because of the way we do business today, a prime contractor can simply make more money selling whole systems than parts of systems. Contractors are interested primarily in two things: short-term profit and long-term corporate wellbeing. But any emphasis today on support items at the expense of whole systems will not allow prime contractors to best achieve these goals.

Why is it important that we understand this? Because to a considerable extent, the requirements we respond to when we buy new systems come from the prime contractor via his marketing and proposal strategies. In fact,

reactive. In addition, because of the priorities established, prime contractors do not adequately consider system support in their initial designs. That's only logical, of course, because they typically make their money delivering airplanes and missiles, not logistics support.

Furthermore, prime contractors usually don't manufacture the parts of airplanes; subcontractors do that. Prime contractors are the assemblers. They make much of their profit, in fact, simply coordinating the efforts of others.

Consider the B-1B bomber. Even though Rockwell is

the system's prime contractor, 54 percent of the B-1's airframe is made by subcontractors. Moreover, Boeing and AIL make the offensive and defensive avionics, respectively; General Electric builds the engines; and many other subtiers of subcontractors exist below them.

The way things are today, the prime contractor must therefore focus primarily on whole systems. But if we buy fewer airplanes and more spares, the prime contractor stands to lose. Such a course of action is hardly the way to motivate him to include necessary logistics support items in his original marketing efforts, which is an important consideration since the prime contractor helps to establish the requirement in the first place. Simple business economics demands that he push for 100 airplanes rather than 90 airplanes and substantial spares (remember, too, that we don't really give him an incentive to provide high-reliability parts, either).

I'm certainly not saying profit is bad. . . . But the profit motive undeniably affects our requirements process by pandering to our infatuation with bigger and better weapon systems at the expense of the spares and piece parts that these systems must have.

Prime contractors must also work to insure the long-term health of their operation. One of the ways they do so is by locking in their subcontractors, usually in a fixed-fee arrangement. In fact, while the prime contractor can take advantage of numerous government incentives, the subcontractor rarely has access to them.

As a result, the subcontractor has no more motivation to meet Air Force supportability needs than does the prime. His real motivation is getting future contracts with the prime; consequently, his principal focus is on satisfying the prime contractor's needs. Unfortunately, the prime contractor's need to make money and our need for supportability and maintainability are usually not compatible.

A closely related cause of our support problems today is the mind-set we have regarding new systems, which we tend to see in terms of the enhanced operational capability they will provide. We can be very specific in our thinking about such operational parameters as mach number, altitude, and gravity loads. Logistics factors, however, receive no such attention from us or the prime contractor. Indeed, logistics requirements are typically couched in such general terms as "three levels of maintenance" and "minimum peculiar support equipment."

Rarely do we consider operational and support requirements as a composite whole. And rarely does a tional parameters for enhanced supportability. Instead, the incentive is for him to produce, for example, high-performance engines rather than lower-thrust, more durable ones.

Don't misunderstand me, however. I'm not saying that the entire acquisition system is bad; indeed, it encourages the "Yankee ingenuity" that has made this nation great. But given the changes in the environment and the challenges we face, it is a process in which we must learn to be more effective.

The first thing we must do is better influence weapon system requirements when they are conceived via the contractor's independent research and development efforts. We must fully appreciate that each prime contractor has in-house design and production capabilities which have evolved over time in response to corporate strategies. Because these capabilities affect the way each contractor views the world, they naturally affect the requirements the contractor will generate.

Altering the prime contractors' mind-sets and methodologies will not be easy. The economics of the process and the sheer inertia of the whole system will tend to impede change. Certainly some of the responsibility for effecting change falls into the political sphere of influence, but much of it must rest on our own shoulders.

Doubtless, we in the Air Force must bear our share of the responsibility for the problems we're facing. For years we have emphasized operational performance and have thereby often driven systems into immature technologies that are difficult to support. We've taken the short-term approach to defining basic requirements, the result being constant system changes. Nor have we always done a good job of articulating the requirement, often hitting the system program managers with "second-thought" or "after-the-fact" needs. And the system program managers themselves have frequently become bogged down in their own day-to-day concerns, failing to trade off parameters at the system level that might ensure long-term, life-cycle benefits.

But substantive changes are under way. With the establishment of the Air Force Acquisition Logistics Division under the Air Force Logistics Command, for example, we mounted a major assault against escalating life-

1977, we shifted control of the deputy program managers for logistics from the five Air Logistics Centers to the Acquisition Logistics Division. A year later, the Logistics Command's Logistics Needs Program established a single corporate overview of acquisition programs and research needs. In October 1983, we joined with the Air Force Systems Command in creating the Air Force Acquisition Logistics Center, which replaces the Acquisition Logistics Division.

In addition, the Air Force has been redressing some supportability problems through a concept known as baselining and a more disciplined systems engineering approach. Under baselining, we are better able to define the threat as well as the major performance parameters required to meet it. We are also addressing key supportability parameters, including funding, and setting up significant program milestones such as design reviews and tests during the process.

Clearly all these efforts represent very substantial progress achieved merely by investing much time and effort. But even with our increased attention to life-cycle cost considerations and baselining concepts, we have yet to address adequately the generic problem of giving defense contractors the incentives to place as much emphasis on supportability and durability as on operational performance.

When we think about performance, we tend to think about systems in a vacuum, a special place where spares and bit parts never need replacing. But today's combat environment is anything but a vacuum; it's hostile, it's real, and it's demanding. In such an environment, given our imperfect systems, performance must be premised on supportability and maintainability.

Defense contractors, therefore, must "sell" their ideas based not on performance capability but rather on the only truly meaningful measure of merit—enhanced force combat capability. Most assuredly, this demands some type of analysis, at the very front end of the process, which points up the optimal combination of performance and supportability to meet the threat. And since weapon systems are typically conceived by contractors, contractors are the logical choice to perform the analysis.

Of course, contractors will do it if it is profitable and if we start insisting on it. But before anything can happen, we must change our current mind-set, our design engineers' penchant for thinking first and foremost in terms of performance parameters. Such a bias is roughly analogous to the American auto industry's out-of-sync fascination with size and power during the 1970s. That it took Detroit almost a decade to change its thinking demonstrates the difficulty in changing mind-vival is on the line.

Needless to say, we cannot afford almost a decade to make such changes in our acquisition process, especially when it would take another decade for the benefits to show up in fielded equipment. In the immediate future, we must attack the mind-sets that already exist, but in time, we must also deal with them when they are being formed in undergraduate and graduate engineering and science curriculums. Like it or not, we tend to train people in our colleges and universities to think and act just as we think and act. Yet this nation's security depends on the design engineers of tomorrow doing a better job than we are doing today.

Like the dinosaur of 60 million years ago, we are now in a very precarious situation; we are effectively out in the open and vulnerable to the threat. Unlike the dinosaur, however, we have the wherewithal to do something about it. We can find ways to motivate prime contractors to include the requisite logistics support in their proposals and marketing. We can find ways to change the mind-sets which emphasize high-tech weapon systems to the exclusion of necessary support items. And, ultimately, we can find ways to make our systems more reliable and obviate the need for such costly impediments as exchangeable spares. In fact, the best thing we can do is work toward the extinction of the logistics burden by emphasizing reliability from the point of system conception.

The passing of the dinosaur cleared the way for the coming of man, the birth of civilization, and the blessings of democracy. Yet our passing would have no such beneficial effect; rather, it would destroy the last real hope for enduring freedom and democracy.

Today, we are at a critical point in the development of military technology; we must evolve if we are to survive. We must, therefore, allow our costly and inefficient reliance on bit parts and spares to pass into extinction before we, once strong and invulnerable, suddenly disappear from the face of the earth. DMJ

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An updated MIL-STD-1388-1: revitalizing logistics support analysis

By JOSEPH D. ARCIERI and RICHARD E. BIEDENBENDER

Recent revisions to MIL-STD-1388-1 are expected to increase greatly the emphasis on readiness and supportability in the acquisition process.

It is a management axiom that large organizations are difficult to manage. Large numbers of people, facilities, and operating locations create complex, intricate interfaces that must be effectively coordinated if organizational objectives are to be accomplished. In the Department of Defense, as in other large organizations, one key to successful management is establishing and implementing comprehensive policy.

Over the past five years DoD has issued new policy directives and updated others in order to greatly increase emphasis on readiness and support in the acquisition process. This renewal of emphasis, which has continued under the Acquisition Improvement Program initiatives of the Reagan administration, focuses on five major objectives:

- Elevating the priority and visibility of readiness and support considerations to the same level of management attention given performance, cost, and schedule.
- Fully integrating readiness and support considerations into each phase of acquisition, with particular emphasis on influencing system design.
- Upgrading the support requirements determination and assessment process by quantitatively relating logistics support requirements to hardware and support design characteristics.
- Establishing readiness objectives and thresholds early in the acquisition process, and extending the use of

analysis and assessment techniques to measure progress.

● Increasing emphasis on front-end development testing and follow-on assessments in order to evaluate the effectiveness of hardware and support characteristics in achieving systems readiness objectives.

The recent revision of MIL-STD-1388-1, "Logistics Support Analysis," is an essential step in achieving these goals. The updated standard, which links policy and contract requirements for logistics support analysis activities, lays out the timing and type of LSA activity to be conducted throughout the system acquisition process. In essence, it outlines a "game plan" for achieving readiness and support objectives (see Figure 1). Since logistics support analysis is the sine qua non of integrated logistics support in the early stages of the acquisition process, one cannot overstress the importance of such a plan. Indeed, logistics support analysis activities provide the information so critical to evaluating design trade-offs, establishing support baselines, enumerating logistics support requirements, and, ultimately, making milestone decisions.

Unfortunately, past use of logistics support analysis has been sporadic and its effectiveness limited due to such problems as:

● Low priority and insufficient funding.

● Too much emphasis on logistics support analysis data-recording.

● Lack of standardization among the services regarding what LSA should do and when it should be conducted.

● Lack of specificity about early LSA requirements.

Most of these problems directly related to the existing guidance in MIL-STD-1388-1 and thus clearly indicated a need for a major overhaul of the standard.

Approach to revitalization. By January 1980, a number of logisticians within the services had formed an informal working group to tackle the knotty problem of LSA revitalization. The group made considerable progress, particularly with respect to the logistics support analysis record, but managers in the Office of the Secretary of Defense and the services generally agreed that a more formal effort was needed.

As a first step, the assistant secretary of defense for manpower, reserve affairs and logistics formed a steering group of senior personnel from OSD and the services in September 1980 to focus top management attention on logistics support analysis and to merge policy thinking with experience from the field. The group's major goals were to develop front-end (pre-full-scale development) LSA guidance and revise MIL-STD-1388-1, continue improving the logistics support analysis record, and address duplication in logistics data requirements. Of the three tasks, the development of improved front-end LSA guidance through the revision of MIL-STD-1388-1 was considered most crucial, since it holds the key to increased readiness and supportability. Thus, the Office of the Secretary of Defense formed a MIL-STD-1388 working group to accomplish this objective.

In the course of addressing existing problems, this

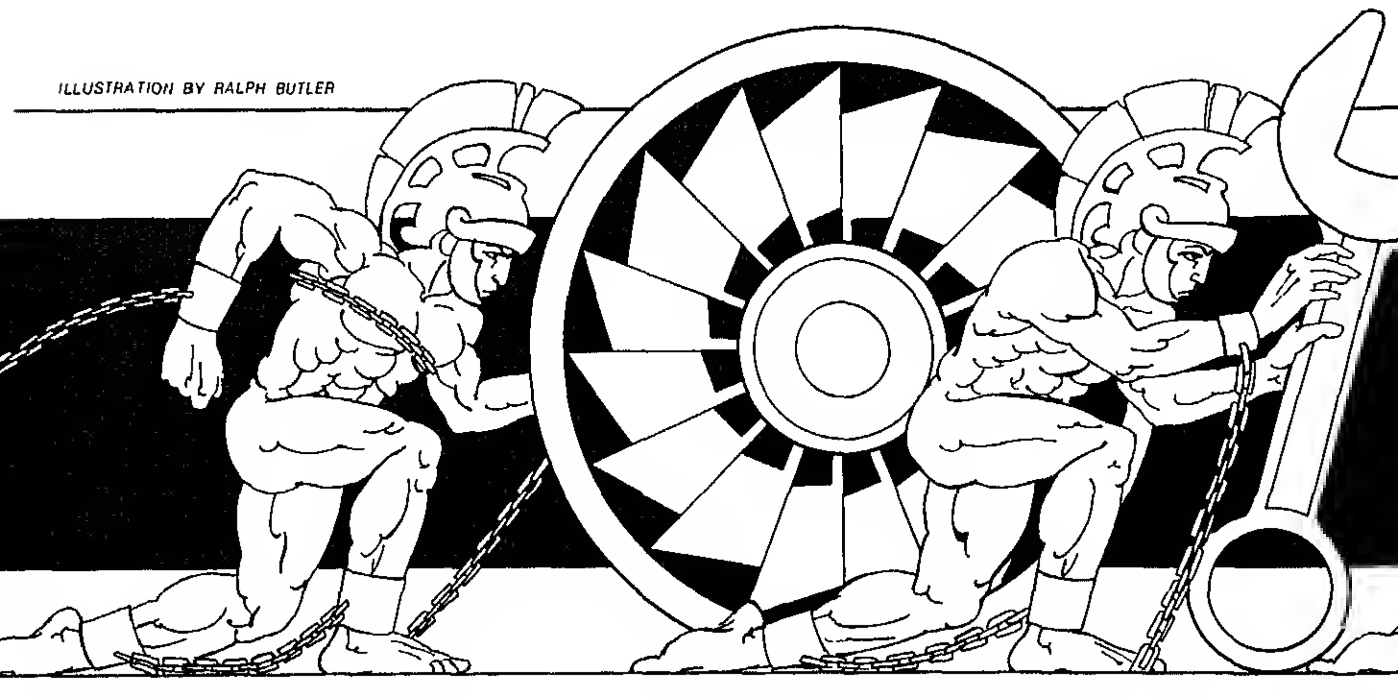


ILLUSTRATION BY RALPH BUTLER

work group decided that the revised standard should:

- Link policy to contracts.
- Be more explicit, yet encourage tailoring.
- Provide a general framework for embedding or referencing specific analysis requirements and methods.

This last point was of special concern, primarily because there are gaps of varying degrees in service data bases and in analysis methods to meet the various requirements in top-level policy documents. For example, methods for relating maintenance grades and skill levels to design alternatives are frequently very subjective. Recognizing that it would take considerable time to fill some of these gaps, the group decided to meet the immediate need by effecting the best possible revision within a reasonable time frame and to satisfy the long-term problem through periodic updates as gaps were filled.

New format. One of the first steps taken by the 1388 work group was to adopt the new format for program-type military standards used in the revision of MIL-STD-785 and MIL-STD-470. Among the many advantages of this format is that guidance on application of the standard is included as an appendix and is thus immediately at hand for the user. The format also encourages specificity and tailoring, both of which the previous standard did not address. The ease of tailoring provides a mechanism for balancing the need for greater specificity against the danger of too much detail. In addition, the structure permits contractual referencing, thereby eliminating much of the need to draft unique

Figure 1. The logistics support analysis "game plan" for achieving readiness and support objectives

PHASE	*LOGISTIC SUPPORT ACTIVITIES*
Pre-concept	Analyze current system for readiness and support drivers Develop LSA strategy Determine system use
Concept exploration	Analyze new system function against baseline system Further define LSA strategy and system use Identify readiness and support-related design factors Identify technology improvements, support alternatives, and trade-offs
Demonstration and validation	Perform detailed design and support trade-offs Compare with baseline systems Refine support concepts Analyze test data
Full-scale development	Optimize support element Identify support requirements Analyze test data
Production, deployment, and post-production	Conduct follow-on tests and evaluations

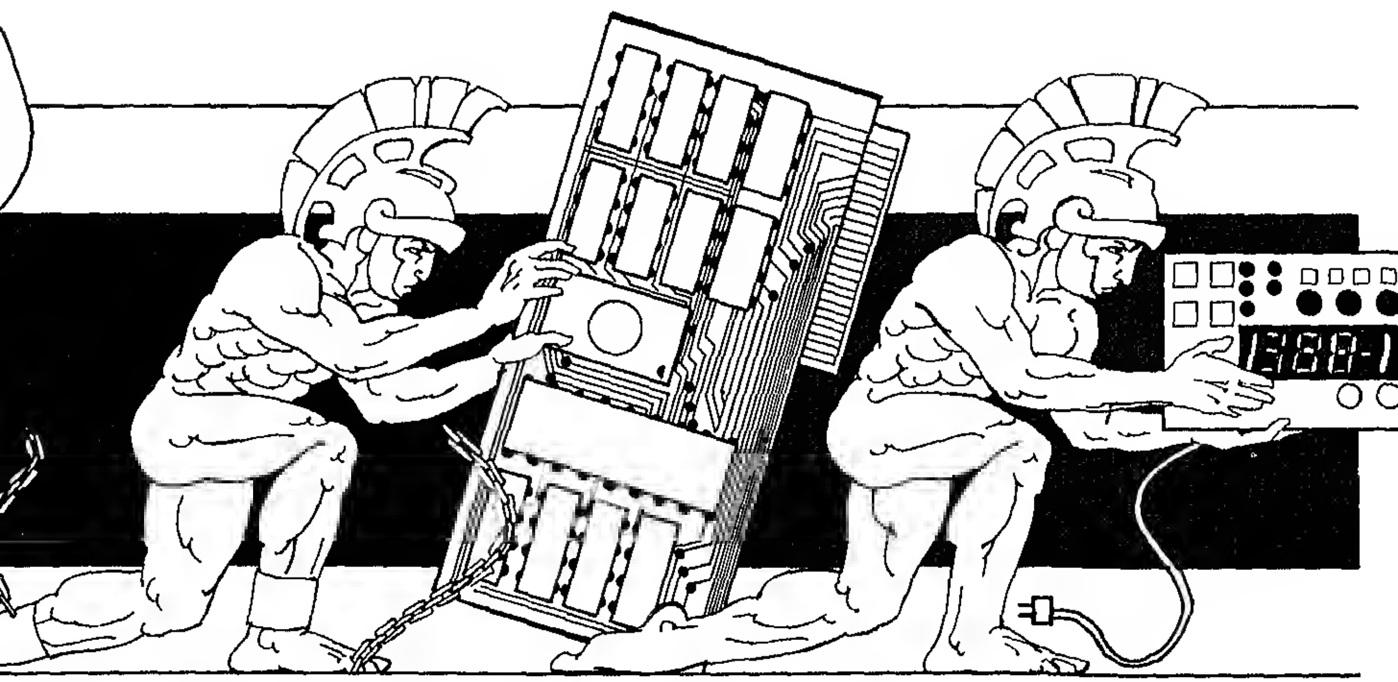
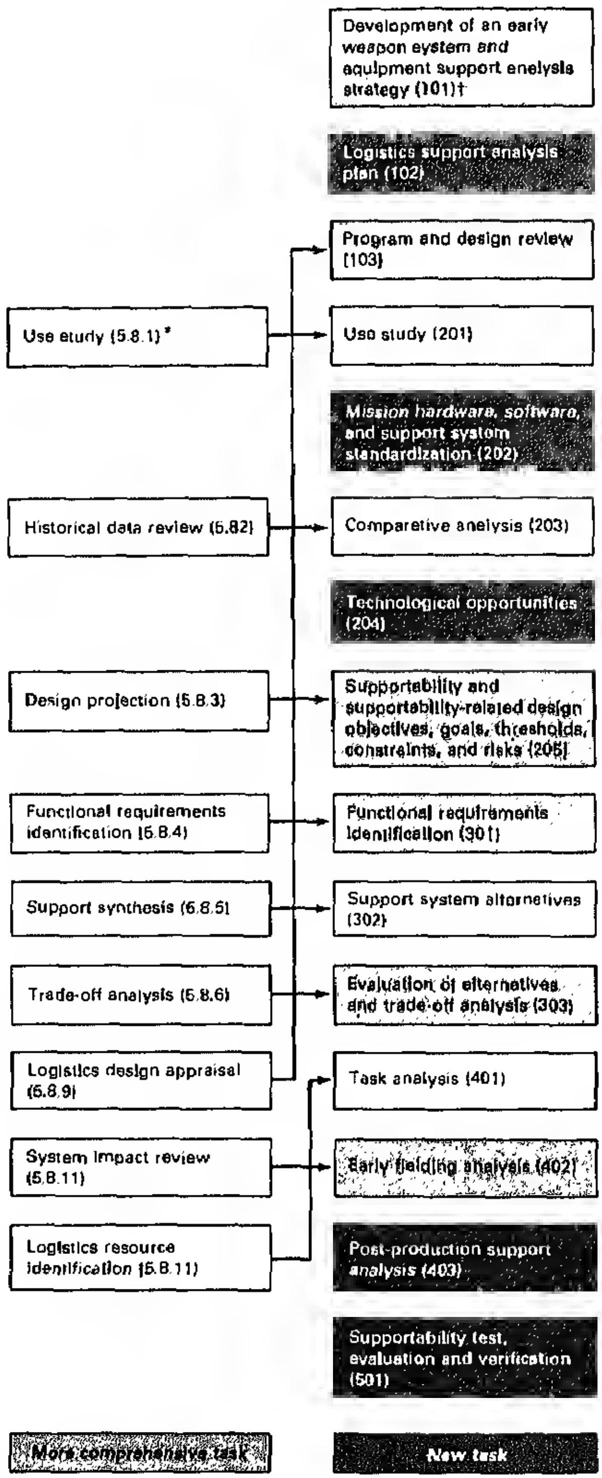


Figure 2. Specific tasks in the revised LSA standard and their relationship to the preceding standard



* Numbers refer to sections of MIL-STD-1388-1

† Numbers refer to task sections of MIL-STD-1388-1A

contract provisions. Finally, the format includes the Data Item Descriptions as part of the Use Guidance.

Figure 2 clearly illustrates the evolutionary character of the new standard. Of nine tasks which appear in the old standard as well as the new, six are defined more comprehensively than before. Five other tasks were also developed to address new policy initiatives and to correct deficiencies in the old standard.

The revised standard groups tasks by section to take advantage of the aforementioned format. Task section 100 includes the tasks necessary for logistics support analysis planning, management, and review. Section 200 contains a series of front-end tasks and subtasks used to derive design and support objectives, goals, and thresholds through comparison with existing systems. Section 300 identifies manpower, cost, and readiness drivers on current systems that must be improved in order to optimize the support concept and achieve the best balance between cost, schedule, performance, and supportability for the new system. Section 400 tasks are directed primarily at identifying support and personnel resource requirements. The purpose of section 500 tasks is to help assess the degree to which supportability requirements have been achieved, both before production and after deployment.

Tasks in sections 200 and 300 strongly emphasize influencing design prior to full-scale development; for example, task 303 contains as subtasks many of the trade-offs common to most programs, including consideration of built-in and automatic test equipment versus manual troubleshooting. It thus helps to fulfill one of the major objectives of the new standard, which is to improve specification of front-end analysis. In effect, the new policy and information requirements are directly linked with the new tasks and subtasks specified in the standard. In many cases, the outputs of the various tasks are actually the analyses and data required by policy directives.

Interfaces. Since logistics support analysis is a multidisciplinary activity, it has many interfaces, including system and design engineering, reliability and maintainability, human engineering, safety, standardization, and the integrated logistics support elements. Coordination of these interfaces to prevent duplication and to cover possible disconnects remains a major management challenge.

One can view these interfaces as input-output relationships. Between milestones zero and one, some of the system-level logistics support analysis involves engineering trade-offs between the hardware and the operating and support concepts. System-level LSA, which itself is an input and subset of these trade-off studies, is in turn based on inputs from various other interfaces.

Figure 3. An example of system-level logistics support analysis interfaces

LSA PROGRAM INPUTS	*INPUT INTERFACES*
Comparative analysis (Task 203)	Design Reliability Maintainability Human engineering Safety Cost estimating ILS elements
Technological opportunities (204)	Design
Supportability and supportability-related design factors (205)	Design Reliability Maintainability Human engineering Safety Cost estimating ILS elements
Functional requirements (301)	Reliability Maintainability Human engineering ILS elements
Support system alternatives (302)	Maintainability ILS elements
LSA PROGRAM OUTPUTS	*OUTPUT INTERFACES*
Objectives, goals, and thresholds	Reliability Maintainability Safety ILS elements
Design and support criteria	Design ILS elements
Targets for improvement	Design ILS elements
Best support concept	Maintainability Human engineering ILS elements

Figure 3 depicts these relationships. The outputs of the system-level LSA are boundary conditions for the interfaces. This process of interfacing continues during the demonstration-validation phase at lower indenture levels. During full-scale development the logistics support analysis record becomes a focal point since it concentrates on the collection and summarization of engineering data, which in turn is used by integrated logistics support managers for further development of management plans. As a further step to address interface requirements and to increase ease of application, the tasks are divided into subtasks and oriented toward specific functional communities such as training and supply.

Although there may be a temptation to greatly increase front-end funding for logistics support analysis, there are nevertheless obvious practical limits. One study, for example, identified over 3,000 possible trade-offs in aircraft systems. Unquestionably, selectivity in application of LSA at the subtask level is essential. To aid the user in this endeavor, therefore, MIL-STD-1388-1A includes an appendix on developing a logistics support analysis strategy.

Such a strategy includes selection and tailoring of tasks and subtasks as well as the development of requirements—to be specified by the requesting activity—which support program readiness and support objectives. This appendix also discusses such major factors affecting the LSA process as:

- The type, nature, and phase of the program.
- The degree of design freedom.
- The time and resources available.
- Experience and historical data.
- Various procurement considerations, such as source selection criteria and weighting, and contractor incentives for reliability, maintainability, and readiness.

In conclusion. Obviously, much high-level attention has gone into the revision of MIL-STD-1388. Unlike its predecessor, the new standard allows for updates as field users provide feedback and as gaps in data systems and analysis methods are filled. Still, the revised standard is only one step in DoD's implementation of new acquisition policy. Moreover, training in its use must be ongoing, as must the updating of the logistics support analysis record. However, the new standard is undoubtedly a major step forward in the evolution of logistics support analysis, which itself is a key to the acquisition of supportable systems. DMJ

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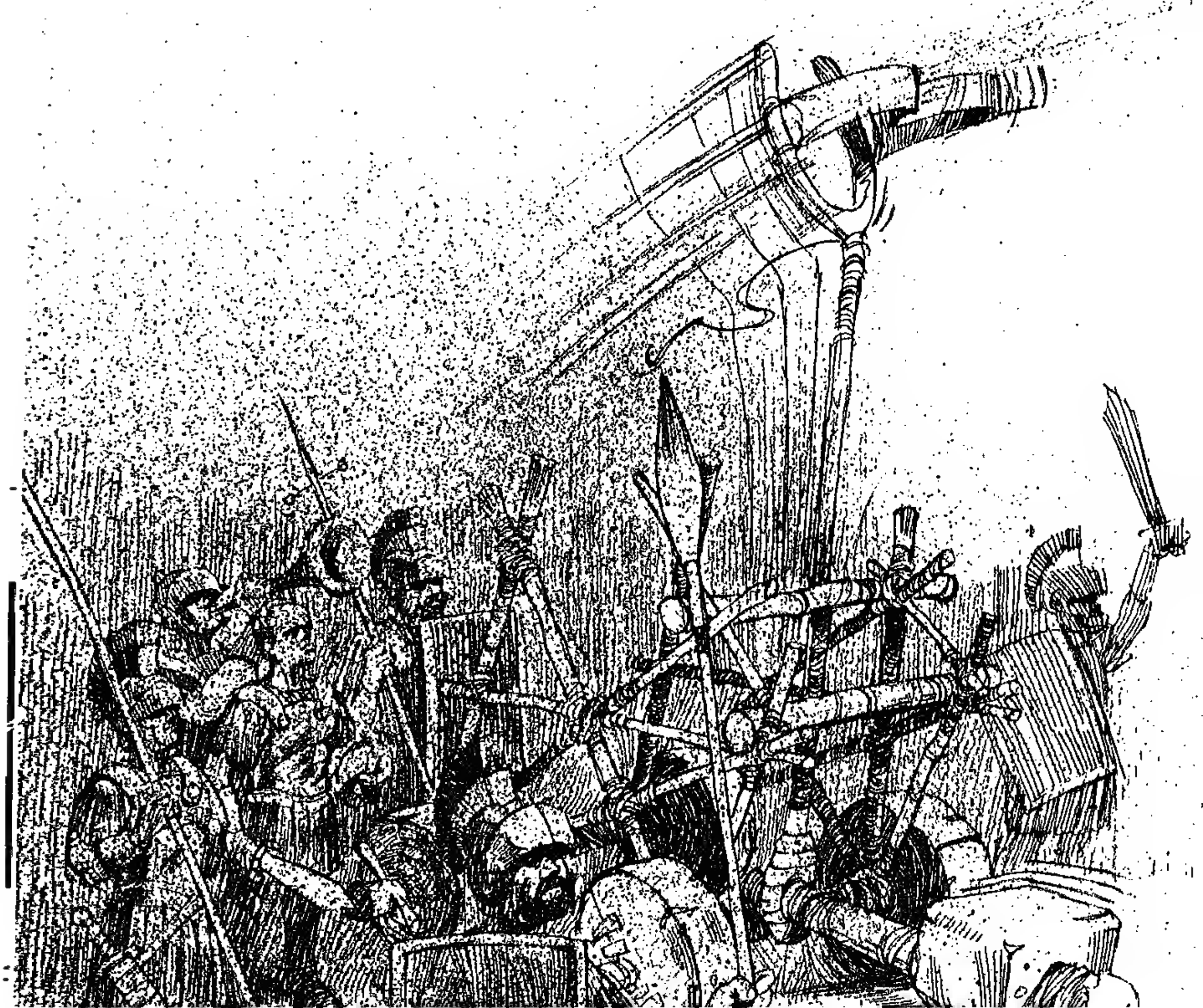
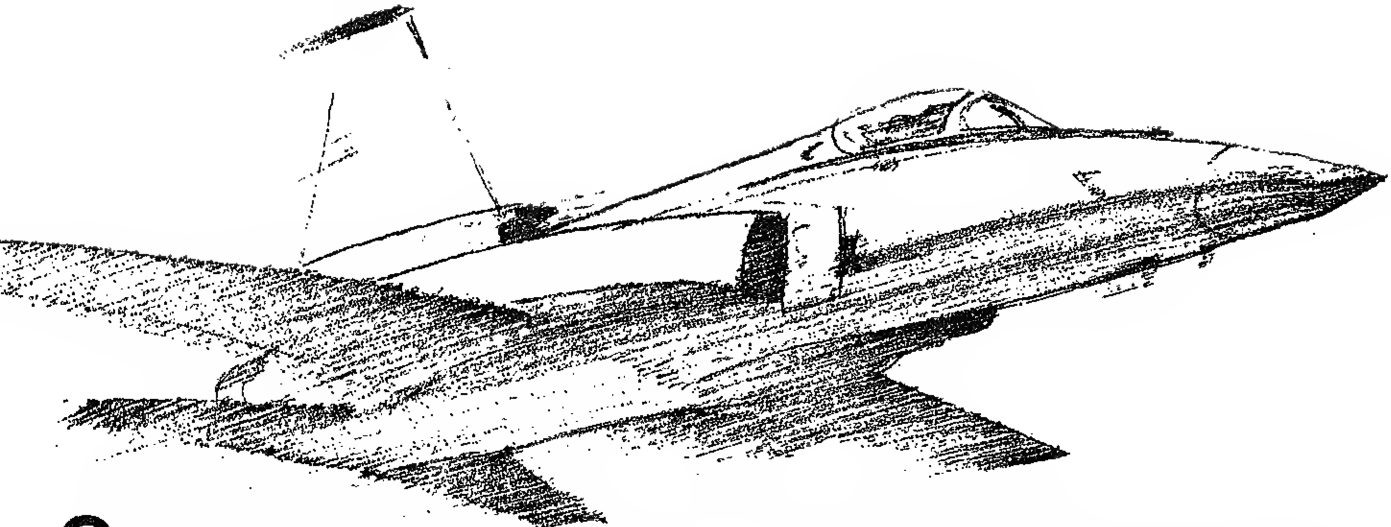
Logistics and the military end game

By THOMAS V. JONES

Greater government-industry cooperation and the application of a little forward-looking imagination are two keys to reversing the poor reliability and maintainability record of our major weapon systems.





One of the members of Julius Caesar's legions charged with the business of supply is alleged to have lamented, "Logisticians are a sad and embittered race of men who are very much in demand in war and who sink resentfully into obscurity in peace." Two thousand years later, however, with the cost of operating and supporting major weapon systems exceeding that of acquiring them, logisticians can ill afford to sink into obscurity. Today, and for as far into the future as one can reasonably see, logistics considerations must command center stage.

By logistics considerations I refer not only to such individual components of readiness as supportability, reliability, engineering, and manpower, but also to the collective whole that is sometimes called the "military end game." This expression implies not only the need for high-performance military equipment that will defeat the threat, but also the need to design and produce equipment that is operationally ready when required and capable of sustaining high rates of mission sorties.

Unfortunately, too many of our current weapon systems require extraordinarily costly logistics support, and even with such support they still are not capable of sustaining their performance during an intense or prolonged conflict. The basic problem is that we have not focused enough attention on controlling operating and support costs at the point of greatest leverage—during the research, development, testing, and evaluation stages of systems development. In spite of much talk about correcting this problem, there has been little progress. The Congress, the military services, and the defense industry have yet to reach a consensus and implement the policies and procedures required to improve significantly the readiness of our systems and reduce their life cycle costs.

However, only through improvements in reliability will our military capability increase substantively and affordably. Consider, for instance, that if the reliability and in-commission rates of aircraft are doubled—an improvement that can be achieved at a fraction of the cost of buying twice as many less reliable aircraft—in effect the number of aircraft that can be committed to the battle is also doubled. While the presence of a particular level of force is important, it is the persistent application of that force that makes the difference between victory and defeat. Such persistence is simply impossible if aircraft are unreliable.

Further, consider the typical distribution of life cycle costs for an aircraft over a 20-year period. Acquisition represents approximately 40 percent of total costs, operations and logistics support more than 50 percent, and upgrades and other items the remainder. The U.S. government and the defense industry are spending billions on computer-aided design and manufacturing, production development techniques, and new manufacturing technologies in an effort to stabilize or reduce the cost growth of acquisition. But only a fraction of that amount is being expended in operations and logistics support—the 50 percent that could be reduced by improving the reliability and maintainability of our systems and equipment. Lower support costs would mean reduced material costs and dramatic savings in associated manpower, maintenance equipment, and facilities costs.

The Reagan administration came into office pledging that readiness would be a main defense priority, and budget estimates show that expenditures for operations and maintenance are expected to increase 46.2 percent from 1982 to 1986. But during that same period, procurement is expected to rise 139.5 percent a d research

budget cuts are negotiated in Congress, or when the Defense Department needs to stretch out its expenditures, funds for readiness are historically the first to go.

But even greatly increased funds for operations and maintenance would not solve the problems of low rates of readiness and high life cycle costs. As the Heritage Foundation recently noted, increased funding for readiness cannot correct the inherent technological and operational flaws that produce frightening records of unreliability in many of our systems. And industry data tend to confirm this conclusion.

According to Northrop studies, only 28 percent of all aircraft failures are induced failures attributable to maintenance errors, secondary failures unrelated to design, foreign object damage, operation outside of design parameters, or handling abuse. The remaining 72 percent of failures are "equipment-inherent," the majority of which are the result of design compromises, deficiencies in technology or manufacturing, or improper instructions for maintenance and repair.

Of course, one must recognize that contractors respond to specifications outlined in Defense Department requests for proposals and requirements documents, which in the past have principally emphasized performance. Reliability and maintainability have not only been underfunded, but more seriously, they have been underappreciated in design and concept formulation. Reliability figures for such current U.S. aircraft as the F-14, F-15, and F-16 reflect the subordinate status of support considerations during these phases.

The emphasis in designing these fighters in the late 1960s and early 1970s was primarily on high performance, with secondary consideration given to reliability and maintainability. As a result, the typical mean-flight-hours-between-failure rate is less than one hour for the F-14, less than three hours for the F-15, and less than four for the F-16. When measured against the criterion of direct maintenance-manhours-per-flight-hour, the government's figures show that these aircraft require anywhere from just under 20 to more than 50 hours of maintenance for every hour of flight.

How can better reliability and maintainability be achieved?

While the presence of a particular level of force is important, it is the persistent application of that force that makes the difference between victory and defeat. Such persistence is simply impossible if aircraft are unreliable.

possible for specific reliability and maintainability requirements to be met at the earliest design stage.

• By investing more money up front in test hardware and by applying a strict new testing procedure called "test, analyze, and fix" during the design and development phase; this new procedure focuses on discovering failures early under realistic performance conditions and then correcting them.

• By developing facts and, in turn, plans that are based on the application of new technologies and by avoiding the use of planning factors based on previous weapon systems to project requirements or predict results.

Let's consider the first of these points in greater detail. In the preliminary design phase, specifying reliability and maintainability as hard requirements, not just goals, is imperative. In establishing these requirements, we must use the latest technology to determine what is realistically possible and we must decide what trade-offs are acceptable in relation to system performance.

The manned space program is a classic example of the benefits such an approach can yield. Reliability was paramount 20 years ago when President Kennedy established the objective of placing a man on the moon. The program succeeded because the nation committed itself to that goal and made the requisite investment in technology development early on. Since then, advancing technology has led to amazing increases in performance, especially in electronics and avionics, but such improvements have tended to obscure the additional progress in reliability and maintainability achieved when these were established as separate objectives.

Allen Puckett, Chairman and Chief Executive Officer of Hughes Aircraft, has formulated "Puckett's Law" to describe the impact of advances in microelectronics technology on systems design. According to that law, technological growth has been so rapid and so profound that a designer of electronics equipment can improve a specified design each year by a factor of nearly two over the previous year; that for a given cost and performance, weight can be reduced by a factor of two; that for a given weight and cost, performance can be increased

by a factor of two, and that for a given cost, weight, and capability, reliability can be increased by a factor of two.

The Navy and Marine Corps followed this law in their efforts to improve system reliability and maintainability on the F/A-18 strike fighter. Concerned about the low in-commission rates of carrier-based aircraft and the high manpower levels required to support them, the Navy targeted the reversal of this trend as a primary objective when it initiated the F/A-18 development program. The service introduced a specific, incentive-based reliability and maintainability program to help achieve results.

The F/A-18 program is an outstanding example of users and producers working together to do things differently. In my experience, it was the first program for which a military service and its contractors agreed to establish reliability and maintainability as parameters equal to performance in the design process. What was needed, they determined, was an organized effort, with up-front money, to develop and test new subsystems at the bench level, the subassembly level, and the final assembly level.

General Electric's F404-400 engine is an excellent example of the success of this effort to greatly improve the aircraft's reliability. From the outset, engineers designed the F404 for mission reliability and ease of maintenance; thus it has fewer parts than any other current fighter engine. For example, in comparison to the J-79 engine, which is in the same thrust class, it has 7,700 fewer parts and weighs little more than half as much. As a result, the F404, which is more than twice as reliable, requires a third less maintenance than the J-79.

Other subsystems that are more reliable, such as avionics and electronics, also corroborate Puckett's Law. The radar, for example, has 8,000 fewer parts than that of the Navy's F-4J, yet it is capable of much higher performance and more complex operations. The F-18's avionics junction temperatures are 10 degrees centigrade cooler than NASA specifications for manned spacecraft and 25 degrees centigrade cooler than permissible military specifications; the result is a great reduction in the heat-induced degradation of reliability.

How well have these exemplary initiatives and other measures succeeded in achieving the F-18's demanding reliability and maintainability objectives?

Consider these data from official Navy reports covering the period June 1981-May 1982: the F-4J's rate of mean-flight-hours-between-failures was 0.9, the A-7E's 1.3, the F-18's 1.8 (and the latter was still in its early demonstration and test phase). Moreover, the F-18 is currently well on its way toward achieving more than 3.0 hours at maturity. The F-4J's direct maintenance-man-hours-per-flight-hour for this period were 30.9, the A-7E's 18.8, the F-18's only 10.3. Again, further improvements for the F-18 are expected over time.

If reliability and maintainability are to receive equal consideration up front, as everyone agrees they should, government and industry must together accept responsibility for establishing the pertinent facts and trade-offs for each particular system.

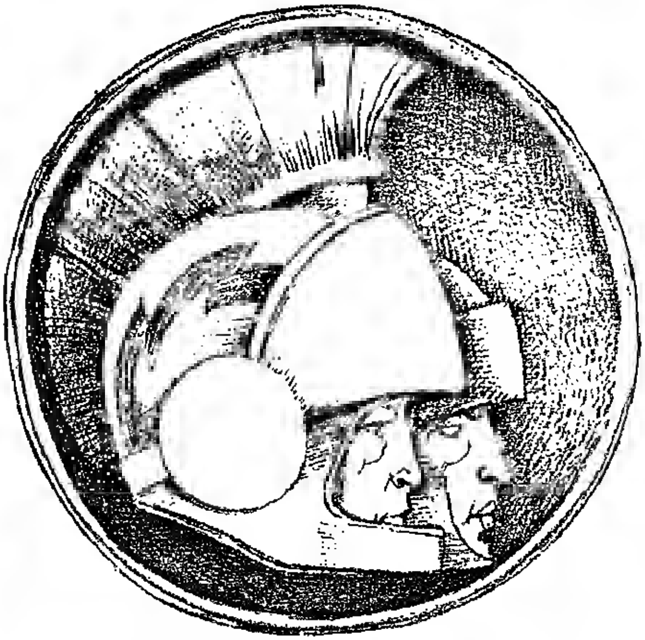
Northrop sought similar advances in reliability in its own F-20 Tigershark, which is company-financed and intended for foreign military sales. Thus far, based on more than 300 flights, the F-20's initial mission reliability rate is more than 98 percent and maintenance expenditures are only half as great as the specified design requirement.

In addition, Northrop has secured firm contractual commitments to reliability from its component suppliers. The subcontract for the F-20's mission computer, for example, calls for an operational mean-time-between-failure rate of 2,100 hours. The head-up display, which allows the pilot to peer from the cockpit while simultaneously viewing flight and weapons information on a transparent panel, has a mean-time-between-failure guarantee of 3,600 hours. The mean-time-between-failure commitments for the radar displays and the inertial navigation set are 4,000 and 2,000 hours, respectively.

The radar is an especially interesting case. Herb Kindl, General Manager of General Electric's Aircraft Equipment Division, testified to the truth of Puckett's Law at the unveiling of the F-20's radar in late 1982 when he said, "Not quite 20 years ago, G.E. developed the F-111 attack radar. From a functional standpoint, the F-111 radar contained about 2,500 active elements. The F-20 contains over 15 million active elements, or an increase in functionality of 6,000 times. If we had to produce the performance of the F-20 radar with 1965 technology, it would require 500 boxes instead of seven. It would weigh 25,000 pounds instead of 270. It would consume 300,000 watts of power instead of 300. And the resulting radar would only have a mean-time-between-failure of 52 minutes instead of the 200 hours

of the F-20's radar. Clearly this radar would have been impossible 20 years ago."

The contractually committed 200-hour mean-time-between-failure rate for the F-20 radar compares to 18 hours for the F-4E, 125 hours for the F-16, and 106 hours for the F-18. Of course, the Tigershark comes 20 years after the F-4E, eight years after the F-16, and five years after the F-18, a clear indication of the technological progress made in the last 20 years.



In achieving these remarkable increases in reliability and maintainability, Northrop has relied on the aforementioned testing procedure called "test, analyze, and fix," first used on the F/A-18. The procedure is a radical departure from traditional methods, under which most equipment testing is done in the laboratory under relatively idealized conditions. Such demonstration tests are deemed successful if the equipment performs up to contractually specified "allowable failure" levels. Yet these "allowable failures" can prove very costly in terms of spares, repair time, maintenance labor, and retrofit changes.

"Test, analyze, and fix," on the other hand, is based on failure discovery testing, which emphasizes inducing equipment failures under the same kinds of realistic conditions to which the equipment will be exposed in operational use. With no maximum allowable failure rates, every failure must be analyzed to determine its cause, to apply the proper corrective action, and to verify by continued testing that the detected failure has been eliminated.

Based on Northrop's experience, only 35 percent of the specific reliability the company is achieving today would have been possible under the traditional testing approach. We could have achieved an additional 25 percent through greater attention to reliability in design. But the remaining 40 percent—the portion that brings us to unprecedented levels of reliability and maintainability—could only be reached by using the test, analyze, and fix procedure under realistic test conditions.

The test data also provide a factual basis for planning the logistics support and the operations and maintenance costs of the F-20, thereby eliminating the need to rely on planning factors, which the military services have too often used to try to represent the future. Planning factors are valuable primarily as a baseline against which to test new ideas. But they have little value as guidelines for future events, for they tend not to recognize technological advances, except perhaps negatively; instead, they tend to carry experience and past mistakes into the future. We should not use planning factors when considering improvements in in-commission rates and maintenance manhours, any more than we do in speed, acceleration, and maneuverability considerations. (Can you imagine using a planning factor to establish the speed or altitude performance of a new aircraft? By faithfully following planning factors, we might never have exceeded the speed of sound.)

If reliability and maintainability are to receive equal consideration up front, as everyone agrees they should, government and industry must together accept responsibility for establishing the pertinent facts and trade-offs for each particular system. Together, we must make the hardware and procurement decisions and, in particular, make the commitment that will allow us to achieve the desired end game result. If we do so, we can achieve major, even startling, advances in capability.

The technology to achieve significant improvements in weapons operability and logistical supportability exists, but we must harness it with forward-looking imagination, not backward-looking skepticism. To fail to do so is to continue to impose unnecessary constraints on the defense budget and this nation's military capabilities.

It is an opportunity we cannot afford to miss. DMJ

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An approach to developing measures of staff productivity

By FRANK M. SHIPPER
and
ROBERT A. SNIFFIN

What factors affect the quality and quantity of work produced by an upper-level staff? The authors of this article outline one approach that yielded some meaningful answers.

Ironically, although headquarters personnel in the Department of Defense establish objectives, work standards, and performance measurements for operational units, until recently few performance criteria have existed for upper-echelon staff employees themselves. With the passage of the Civil Service Reform Act and the advent of the Senior Executive Service and the Merit Pay System, however, development of such objectives, standards, and measures has become imperative. Underscoring the need for these criteria are the initiatives DoD has under way to improve productivity, for the quality of upper-level staff performance directly and significantly affects not only productivity but the long-term success of an organization as well.

But what does management need to know in order to assess how well a headquarters staff is performing? What factors affect the quality of work accomplished at this level? A program carried out at the Naval Material Command in 1980-81 provides some answers to these questions and illustrates one approach to formulating quality assessment criteria for upper-level personnel. Given current trends within the labor market, the results of this and similar programs are likely to play an increasingly prominent role as the nation seeks to boost its productivity.

Historically, measurement of performance and productivity has focused on the blue-collar, profit-oriented, industrial segment of the economy. But the nation's economy is changing rapidly. Manufacturing now ac-

Figure 1. In devising measures of performance among members of a Navy staff operation, researchers derived this list of thirty deviations from the ideal

DEVIATION ORIGIN	Demand point outside of system	Division level	Branch level	Action officer level	Outside the system other than demand point	
Fuzzy or unclear tasking	X					
Fuzzy or unclear guidance		X	X			
Delayed action officer receipt due to administrative delays	X	X				
Conflicting priorities	X					
Inconsistent task assignment		X	X			
Excessive coordination delays			X	X		
Arbitrary deadlines	X	X	X			
Inadequate policy decision promulgation	X	X	X	X		
Word processing center inefficiency						X
Misdirected tasking	X					
Secondary confirmation required	X	X	X			
Policy limiting original staff work	X	X	X			
Inconsistent multilevel extension approval	X	X				
Inadequate inputs from supporting or coordinating organizations					X	
Typing delays						X
Inefficient handling of hierarchical tickler system	X					
Excessive copying of administrative documents		X	X			
Rewrite for style	X	X	X		X	
Tasking not through normal chain	X					
Mailroom delays	X				X	
Nonresponsive action from support or coordinating organizations					X	
Excessive clerical burden on action officer			X	X		
Too many tickler systems	X	X	X			
Overemphasis on reaction, not proaction	X			X		
Perceived importance of task due to requestor's rank				X	X	
Not included in chain until crises arise	X				X	
Biased or restrictive guidance			X	X		
Lack of acceptance or credibility					X	
Day-to-day working relations (internal communication)				X		
Lack of signature authority			X	X		

counts for only 30 percent of the U.S. labor force, down from 65 percent in 1950, while the traditional service sector has remained relatively stable at 11 or 12 percent. The segment of the work force involved in creating, processing, and distributing information, however, jumped from 17 percent in 1950 to 55 percent in 1980. Though banks, stock markets, insurance companies, and educational institutions are all organizations rich in information workers, the fastest growing area within this sector is government, which now employs one out of every five workers. Since government staffs have grown even faster than operational units, adequate, valid measures of staff performance and productivity are a pressing need in the civil service.

Staff size has burgeoned as staff and support work have become more critical to the missions of both civil and defense agencies. Due to greater technological sophistication and more complex governmental rules and regulations, the demand for staff functions such as legal briefs, environmental impact statements, affirmative action plans, and fiscal reviews has grown for all major contracts, programs, and initiatives. With the advent of shared weapon systems, the need for coordination among the various line and staff offices across commands and services has further enhanced the importance of staff offices. If today's high-technology military is to be effective, staff and support personnel must first do their jobs and do them well.

To devise measures of staff performance and productivity for the Naval Material Command project, program coordinators followed a six-step approach based on variance technique. (The basic procedures for this approach were developed by Everett E. Adam Jr., James C. Hershauer, and William A. Ruch and are described in *Measuring the Quality Dimension of Service Productivity*, National Technical Information Service Report Number PB-282-243, U.S. Department of Commerce, Washington, DC, 1978.) Project personnel first developed a schematic representation of the organization and interacting organizations and then prepared a flow chart depicting the operational steps for satisfying demands under ideal conditions. After identifying deviations from the ideal, they screened the deviations to separate key ones from the trivial. The approach next called for staff from the organization to help formulate measures of the key quality deviations; the final step was selection of valid measures by top managers from the organization.

This approach had two principal advantages. The study team did not have to derive actual costs on in-

gure 2. Researchers winnowed out all but these nine key deviations by ranking em according to their importance to staff work and their effect on its quality

nphesis on reaction, not proaction	The degree to which projects assigned are short-term, atypical, and reactive rather than preventive or directed at underlying causes
or unclear tasking	The degree to which tasks assigned by entities external to the division are ambiguous
or unclear guidance	The degree to which assignments made by one level to another within the division require additional clarification
ry deadlines	The degree to which assigned deadlines are administratively driven and not organizationally or functionally appropriate
ting priorities	The degree to which priorities are in conflict, either for administrative or functional reasons, and must be resolved
e for style	The degree to which responses are rewritten to comply with a mode of expressing thought, fashion, manner, or tone unrelated to clarity
sponsive action from support or nating organizations	The degree to which those organizations do not respond to requests for action
uate inputs from supporting or nating organizations	The degree to which the responses received from those organizations are inappropriate, unclear, untimely, inept, or irrelevant
sive coordination delays	The degree to which required correspondence reviews are administratively driven and not functionally appropriate, or are otherwise hindrances to timely completion

ique required that the purpose of services pro- clearly identified rather than stated in broad ations such as "to serve the fleet."

consultants from the Naval Material Com- Productivity Management Office served as pro- ordinators. The headquarters staff unit that red to participate was a division consisting of ches and approximately 30 individuals. In per- its assigned functions, the staff unit works with fices in headquarters, such as budgeting, per- logistics, and acquisition, and also with tions external to headquarters.

nd for the division's services may be either pro- d or unprogrammed. Programmed demand rom the requirements of assigned projects and s—periodic reviews of major weapon systems, ple. Unprogrammed demand usually takes the messages, letters, and phone calls from various sources, including higher echelons within head- , special boards, and operating unit com- . It may be a query concerning the status of a r problem system or a request to draw up an ac- n to resolve the problem. More than 90 percent entifiable demands received by the division were ammed and required well over 90 percent of the ime.

dless of the originator or type of demand, ideal- nit operates as follows. The division receives a for service and assigns it as a task either to a hin the division or to an individual employee. ng a period of research and information gather- ing by that group or individual, the division takes one of three courses of action to satisfy the demand. It forms a study group, tasks a subordinate or supporting organization to provide the service, or contracts the service out. Division personnel then draft a formal response to the demand, forward it for typing, review, and signature, and send it to the originator.

Researchers used this model as a starting point for determining how operations may deviate from the ideal. To identify such deviations, which are critical determinants of staff performance and productivity, researchers used a nominal group brainstorming process. This process, a structured technique for generating ideas, develops a larger quantity and better quality of ideas than free association brainstorming. On this project, it involved a cross section of nine individuals from the staff unit in addition to the two program coordinators. The process consists of at least two iterations, during which participants silently write ideas on their own, then list those ideas in round-robin fashion for the group on an easily readable medium, and finally clarify the ideas listed.

Deviations represent organizational variances which need to be controlled. To focus solely on the quality of staff productivity, the process excluded faults in technical subsystems, such as word processing, from consideration. The Naval Material Command group eventually arrived at a list of 30 deviations and ranked them on the basis of two criteria: importance to staff work and effect on quality of staff work (see Figure 1). The coordinators considered both these rankings plus the follow-

Figure 3. By averaging validation scores across all respondents, researchers were able to pinpoint with a strong degree of certainty the measures which merited inclusion in a formal measurement system of staff productivity

Deviation	Measure	Weight*
Overemphasis on reaction, not proaction	Number of work hours expended on proactive work / Total number of hours worked	.333
	Number of proactive tasks postponed due to reactive tasks / Total number of proactive tasks	.138
	Number of tasks assigned to appropriate action officer / Total number of tasks	.133
	Number of requests to clean up outstanding tickfore on items previously completed and signed / Number of tasks completed	.076
	Number of tasks assigned to appropriate branch / Total number of tasks	.058
Fuzzy or unclear tasking	Number of tasks requiring follow-up events, such as meetings or calls, to obtain clarification / Total number of tasks	.210
	Number of hours spent clarifying tasks / Total number of hours worked	.125
	Number of days to obtain clarification / Total number of days to complete task	.085
	Number of completed tasks returned by originator with added guidance to modify, amplify, or readdress various issues / Total number of completed tasks	.085

* Only measures averaging .05 or higher were recommended for inclusion.

ing questions in selecting key deviations from the original list of 30:

- Was the deviation process-oriented?
- How frequently did it occur?
- Of what magnitude was its effect on processing the demand? (Coordinators considered both usefulness and timeliness in assessing magnitude.)
- What impact did the deviation have on the organization's mission? Figure 2 (p. 19) lists the key deviations identified.

A second brainstorming session followed, during which program coordinators met with the nine division members to discuss how best to measure deviations that were most important to the organization and that most affected quality. Quality in this context was the degree to which the product or service either conformed to a set of predetermined standards or was acceptable to the next higher echelon. This session yielded 156 ideas for developing measurements, and the coordinators used these ideas to formulate 94 ratio measures. The measures in turn became the basis for a validation questionnaire.

The purpose of the questionnaire was to ascertain the degree to which the measures were applicable to a deviation and the degree to which the rater felt certain about that applicability. For the deviation "Overemphasis on reaction, not proaction," for example, the two ratios were "Number of tasks initiated by headquarters-managed programs-to-total number of tasks" and "Number of reactive tasks-to-total number of tasks." The questionnaire asked respondents to complete two statements about each ratio: "I believe this measure for this deviation is: poor, satisfactory, or good"; and "I feel that my degree of certainty is: very strong, strong, or moderate." Program personnel submitted the validation questionnaire to the division director, the deputy division director, and all branch heads.

The scales applied in order to obtain a validation score for each measure were, for the "belief in measure" response, poor (−0.8), satisfactory (0.1), and

good (1.0), and for the "degree of certainty" response, very strong (0.9), strong (0.5), and moderate (0.1). (The scales selected reflect the closer correlation between the "belief in measure" response and the concept of validity.) Multiplying the score for the first response by the score for the second yielded a validation score for each measure. Those scores ranged from a low of −0.72 (−0.8 for poor belief times 0.9 for a very strong degree of certainty) to a high of +0.9 (1.0 for good belief times 0.9 for a very strong degree of certainty).

By averaging validation scores across all respondents who evaluated a particular measure, researchers derived a group validation score for that measure. The program coordinators recommended only measures averaging +0.05 or higher for inclusion in a measurement system. That cutoff point reflected at least a satisfactory belief in the measure with a strong degree of certainty. Figure 3 lists the quality measures of staff productivity that survived this cutoff, in descending order of validation rating, for the first two key deviations. The range of scores under a deviation reflects the rankings obtained from the validation group of managers. That group considered a total of 29 quality measures valid.

Through follow-up interviews with both management and staff, researchers assessed the immediate benefits of the measures development process to the participating organization. Highlights of those benefits, reported independently by the two groups, included the following.

Participants agreed that the project provided a forum for constructive interchange of ideas, thereby opening communication channels and affording a vehicle for bringing problems to the attention of top management. Division personnel considered this benefit particularly important because management of the organization had changed recently, but due to the press of everyday business, management had not been able to do a systematic study of organizational needs. Also, exposure of branch-level personnel to the experiences of other branches in the division helped broaden the perspective of the participants.

In addition, the process demonstrated the steps involved and hindrances encountered in executing assignments. Given the constantly changing demands of a largely unprogrammed workload, no one had previously tried to rationalize the process. This study highlighted recurring stumbling blocks, regardless of the request or branch involved, and thus enabled management to remove some of the obstacles to speedier accomplishment.

Stronger group identity was another benefit. Up until the time of the study, branches only infrequently interacted with one another or collaborated on projects, because the nature of their duties rarely required such working relationships. The physical location of the branches on different floors of a large office complex had further hindered formation of a division identity.

The project also established a baseline for defining individual job requirements and performance goals more precisely. Before the study, top management's primary criterion in assessing performance had been timely accomplishment of assigned projects. The project gave management more than 30 measures to use in developing the individual staff objectives that a new performance appraisal system required.

Finally, the pilot program proved the feasibility of developing measures of the quality of staff productivity. Although developed for one division, the measures appear, after preliminary examination, to have applicability to other organizations. Their appropriateness and validity within any one or across multiple staff units, however, need further investigation and testing. The final determination of which productivity measures are both applicable and feasible will have to occur at the organizational level at which they are being used. This step will ensure that the measures selected are not only appropriate but that the organizations are committed to the measures as well. DMJ

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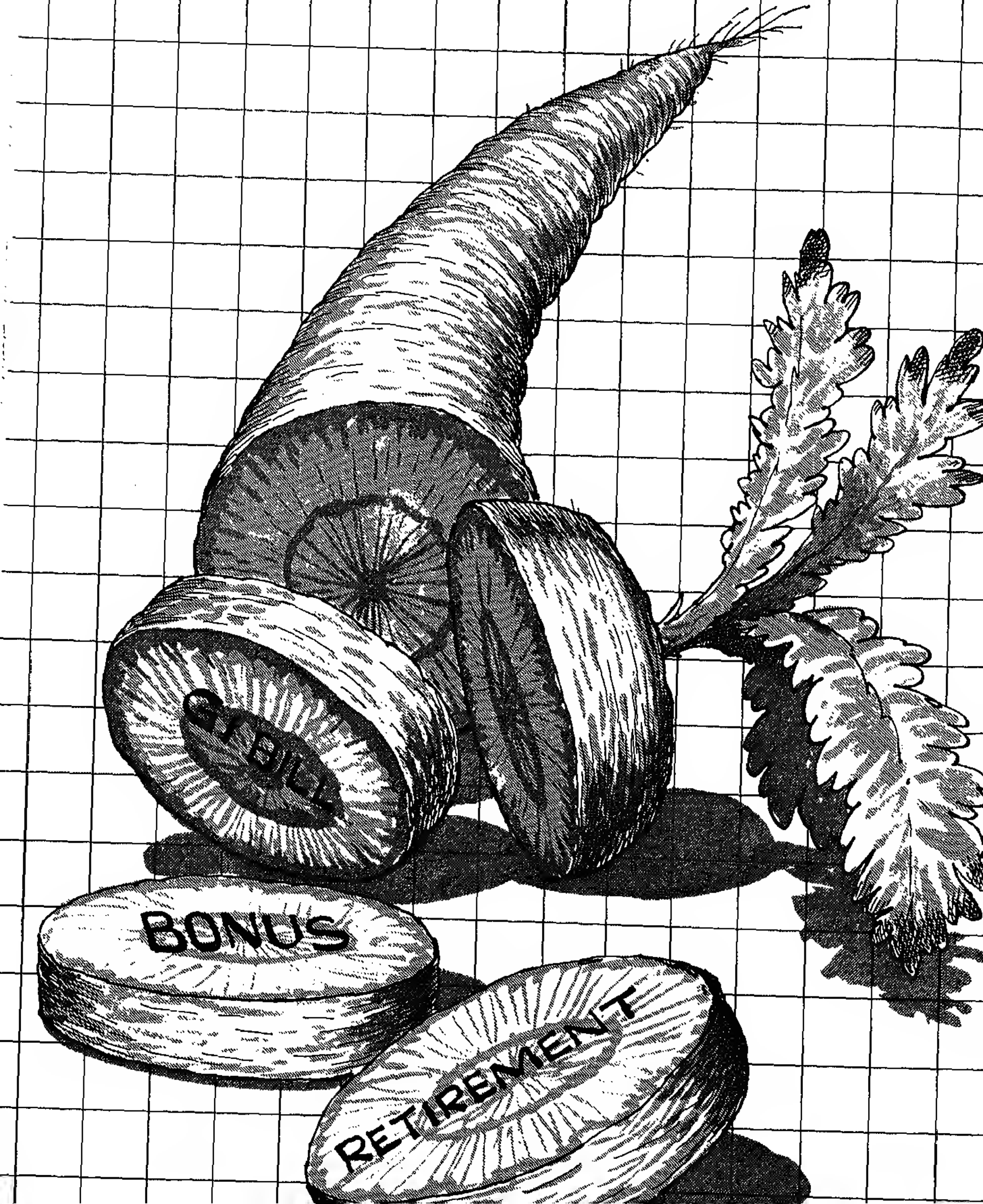
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BONUS
RETIREMENT

Issues in evaluating military compensation alternatives

By JOHN T. WARNER

Although economists and defense analysts agree on the need for effective military compensation policy, they often differ on the best means to achieve that end.

One infrequently discussed, but very significant, factor directly affecting military compensation policy is the effect of the variance in perspective of the individual analysts, economists, and military personnel who work in this critical area.[1] Having spent the last seven years as a defense manpower analyst, I have concluded that economists view compensation issues quite differently from everyone else.

This article considers the approach that economists take in dealing with the following major military compensation issues: the yearly pay adjustment mechanism, the mix between basic military compensation and various discretionary items, the mix of enlistment incentives, and the mix between active-duty pay and retirement benefits. Because economists alone do not determine compensation policy, the article sets their thinking within the context of arguments advanced by analysts from other fields and discusses external influences that also temper decisions on military compensation.

Four primary characteristics seem to distinguish the economic approach to military compensation issues. The first, largely a concern for efficiency, holds that the goal of manpower managers should be to determine which set of compensation and personnel policies will yield the desired force at the least cost. This concern contrasts with those of many others who tend to weigh more heavily such considerations as equity or fairness.

The second characteristic is a belief that people respond to incentives; specifically, higher military pay increases supply while lower pay reduces it. Numerous studies confirm this proposition.[2] In fact, these studies have found that enlistment supply changes by 10 to 15 percent—and retention responses by as much as 30 percent—for each 10 percent change in military pay. Yet, despite this clear evidence that accession and retention supplies are quite sensitive to pay, policymakers frequently make decisions about military compensation on the implicit assumption that their actions will not affect supply.

This is not to argue that pay is all that matters, as economists are frequently misinterpreted as saying. Recent research has shown, for example, that nonpecuniary factors such as the extent of sea duty and the frequency and duration of family separations

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[1] *Richard V. L. Cooper, in "Military Compensation Policy," discusses many of the issues raised here in considerably greater detail. Complete documentation for this and other citations and quotations not specifically or fully footnoted will be found in the references on p. 29.*

[2] *See the initial enlistment supply studies by Richard L. Fernandez, David W. Grissmer, and Lawrence Goldberg and the reenlistment supply studies by Winston K. Chow and Michael J. Polich, John H. Enns, Samuel D. Kleinman and William E. Shughart, David Rodney et al., and John T. Warner and Matthew S. Goldberg.*

significantly affect retention decisions.[3] Indeed, many policymakers prefer improvements in these factors over adjustments in pay as a means of bolstering recruiting and retention. But to an economist, the important question is what mix of pay and nonpecuniary enhancements will provide the desired force at least cost.

The third characteristic of the economic approach recognizes that people have different preferences for various consumer goods and services. This diversity implies that the compensation system should rely primarily on cash incentives. They will be more efficient than noncash incentives, unless most personnel value the latter at least at the cost of supplying them or unless the government has a true cost advantage over the private sector in supplying the noncash incentive, as it does, for example, in providing medical care for dependents. (Since the government already maintains a large medical system for contingency purposes, it can offer some medical services for dependents at low cost.) The issue of diversity of preferences leads economists to question the efficiency of many elements of the military compensation system, which relies heavily on noncash benefits.[4]

The fourth characteristic, which is perhaps most fundamental to the economic approach to military compensation issues, is that personnel prefer current dollars to future dollars. Two recent studies show that this preference for current dollars is greatest among young personnel. One study done by Harry J. Gilman for the Center for Naval Analyses and another by James Heckman estimate that young personnel have yearly discount rates exceeding 15 percent. In other words, they would prefer $1 of compensation today to any amount less than $1.15 next year. This proposition guides economists' thinking about a number of compensation issues, particularly the structure of the bonus and retirement systems. Its influence and that of the other three primary characteristics will be evident in the discussion of specific compensation issues that follows.

By law, military pay is to be adjusted yearly, along with the pay of federal general-schedule employees, based on the results of the Professional, Administrative, Technical, and Clerical Survey. Although the intent of this process is to maintain a stable level of military pay relative to civilian pay, in practice the adjustment process has not worked. Faced with mounting budget deficits in the latter half of the 1970s, Congress frequently capped the federal pay raises below the level targeted by the survey. As a result, federal civilian and military wages increased less than was needed to maintain comparability with the private sector. Military pay fell further relative to civilian pay for other reasons as well, including reallocations from basic pay to allowances, a substantial reduction in first-term reenlistment bonuses, erosion of the value of fixed compensation items, and elimination of the GI Bill.

The substantial decline in military accession supply and career retention that occurred between 1976 and 1979 was no doubt due in part to these changes. By contrast, the sizable increase in accession supply and career retention between 1980 and 1982 was due in part to the fact that Congress suspended the link between federal civilian and military raises. Instead, it voted the military two significantly larger increases aimed at restoring the relative pay level that existed in the mid-1970s.

Moreover, as was noted at the Center for Naval Analyses Manpower Conference in June 1982, not all pay caps were the fault of Congress. Before 1980, DoD and the services had very little capability to forecast how force structures were likely to evolve under alternative pay scenarios; as a result, they were not able to articulate what impact pay caps and other pay reductions would have. Fortunately, several recently developed models have significantly enhanced the ability to project such impacts.[5]

But even improved forecasting tools will not obviate the need to reduce political influence over the military pay adjustment process if we are to avoid the large fluctuations in recruiting and retention that occurred during the early part of the all-

[3] *See Winston K. Chow and Michael J. Polich, "Models of the First-Term Retention Decision," and John T. Warner and Matthew S. Goldberg, "The Influence of Non-Pecuniary Factors on Labor Supply" and "The Determinants of Navy First-Term Retention Behavior in the AVF Era."*

[4] *See the* Final Report of the President's Commission on Military Compensation, *pp. 101-110.*

[5] *See Glen Gotz and John McCall, "Estimating Military Personnel Retention Rates," and John T. Warner, "Alternative Military Retirement Systems."*

volunteer force era. While it would be naive to think this influence can be eliminated, given the routine pressures on Congress, an independent military pay board could perhaps minimize its effects. Such a board, which the Defense Manpower Commission proposed in 1976, could track compensation and retention trends and recommend to Congress the form and level of yearly pay raises.

An independent board might also be able to address other deficiencies in the current pay adjustment mechanism, in particular those relating to the Professional, Administrative, Technical, and Clerical Survey. Due to several problems inherent in the survey, even annual military pay raises granted in strict accordance with its findings would probably be inadequate to maintain comparability. As Christopher Jehn reported in a study done at the Center for Naval Analyses, the survey is not representative of the jobs performed by most enlisted personnel and many officers. According to the study, any comparability of wage growth among private-sector and military jobs most comparable to one another would only be happenstance.

Another problem in using the survey is that it does not adjust for developing trend biases. The composition of the civilian labor force with regard to age, sex, and race, for example, has changed dramatically in the last 10 years; the labor force is younger and has a larger fraction of women and minorities. Since these groups tend to have lower-than-average earnings, a survey of private-sector wages that does not control for the changing composition of the labor force will show slower wage growth than each member of the civilian labor force is actually experiencing.

Because the survey is based on the wages of *employed* workers, a related bias tends to impart a pro-cyclical bent to the wage changes needed to maintain comparability. Since lower-wage workers are more frequently laid off in a cyclical downturn, the survey typically shows more wage growth during a recession than has actually occurred. By contrast, employment increases in an improving economy are disproportionately greater among lower-wage workers and bias the rate of wage growth downward. Thus, the survey tends to overstate wage increases needed to maintain comparability during cyclical downturns (FY 1974 and FY 1975, for example), but understates the increases required during expansionary periods (for example, FY 1976 through FY 1980). As a result, comparability increases based on the survey, even when granted, are likely to lead to cyclical fluctuations in recruiting and retention. The only solution to these problems is developing a better index.

Mixing basic and discretionary items

Some economists believe that even if a better index linking military and civilian pay were devised, recruiting and retention problems would remain. They argue that occupational imbalances would still exist because the military uses a single pay table for all occupations, and the services either lack or fail to utilize fully the discretionary items of compensation available to eliminate imbalances. More than 90 percent of military compensation is in the form of nondiscretionary items, including basic pay and allowances, retirement benefits, and other entitlements. Though reenlistment bonuses and other discretionary items are a larger fraction of total compensation in the Navy than in the other services, such items made up only about 10 percent of outlays for personnel in FY 1981.

Failure to compensate according to occupation is an outgrowth of a philosophy that stresses equal pay for equal responsibility. This philosophy holds that pay should vary by rank and experience, not by occupation; it views as unfair the notion that personnel of similar rank and experience should receive different pay just because they are in different jobs. Its proponents also contend that too much variation in compensation is undesirable because it leads to lower performance and to morale problems, at least among those in the lesser-paid occupations. A corollary to this philosophy is that general pay raises must be used to solve recruiting and retention problems.

Economists object to the inefficiency of such an approach. Because supply and demand conditions vary considerably across occupations, at a given pay level some occupations may be experiencing shortages, while others are experiencing surpluses. General pay raises are therefore costly solutions to shortages that exist in only some occupations.

bonuses, and greater reliance on special and incentive pays, they nonetheless disagree considerably over which options to increase most.

Many economists prefer expanding the use of reenlistment bonuses because they are the most flexible of the options available and need only be paid at career points where retention is a problem. Moreover, unlike general pay raises, bonuses minimize the superfluous money or "rents," in the economist's jargon, paid to those who would have stayed without a pay raise.

Most economists also favor lump-sum bonuses, which DoD instituted in FY 1979, over installment bonuses because, given the non-zero, real discount rates referred to earlier, the former have greater impact on retention. In addition, since bonuses are now based on paygrade at reenlistment, inflation reduces the real value of future, fixed installments and hence their retention effect as well.[6] For this reason, economists recently opposed a policy change to award bonuses half in lump-sum and half in installments.

Although expanding the use of bonuses is a simple remedy with much merit, several arguments have been advanced against this approach. For example, bonuses—especially lump-sum bonuses—are not a highly visible element of compensation; surveys show that personnel tend to forget about their bonuses when asked about their compensation level. Also, there is the somewhat paternalistic fear that most lump-sum bonus recipients will squander the money on a new car and then spend the next several years starving and regretting that they reenlisted; this argument suggests that lump-sum bonuses may have a detrimental effect on subsequent job performance. Another problem is recoupment of bonus payments from those who fail to complete their obligations, although loss rates from such personnel are admittedly quite low.

One way to alleviate these problems is to incorporate bonuses into the recipient's monthly pay check and base each payment on the individual's even eliminate, the effect of inflation on fixed installment payments, while at the same time increasing the incentive for personnel to perform and advance.

Another major problem with the bonus program is that when the cap on bonus payments is effective, it induces personnel to reenlist for shorter periods. Even with the recent increase in these caps, personnel in occupations carrying more than a level-3 standard reenlistment bonus multiple may receive the maximum bonus for only a three- or four-year reenlistment. In a 1982 study of Navy first-term retention behavior, Matthew Goldberg and I found that these caps have had a substantial detrimental effect on the length of reenlistment in the Navy. DoD should eliminate the caps and revise the bonus program so that it is essentially a system of multiple pay tables for those length-of-service cells in which bonuses are awarded.[7]

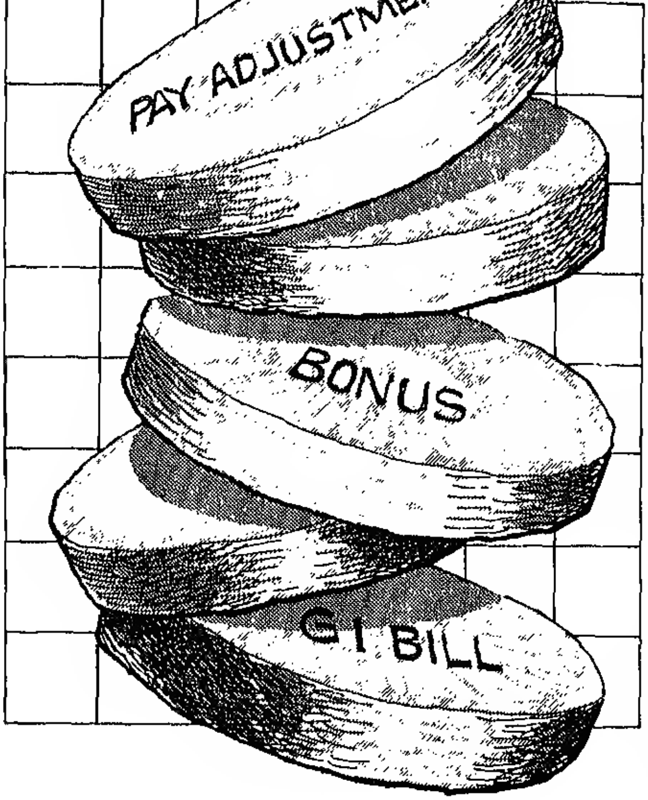
Special and incentive pays

In addition to introducing more flexibility into the compensation system, the major argument for greater reliance on special and incentive pays is that they offer inducements that bonuses do not. Bonuses, for example, provide no extra incentive for personnel to accept less desirable assignments or to perform and advance as would a well-structured system of incentive pays. Special pays like sea pay encourage personnel to accept more arduous assignments. Indeed, the Navy has experienced significant increases in voluntary extensions to sea duty in the wake of the new sea and submarine pay rates. The recent sea pay increase is especially important because voluntary extensions to sea duty, coupled with the higher retention brought about by sea pay, may prove to be the least costly way of improving ship manning.

The primary argument against increasing the use of special and incentive pays is that, unlike bonuses, they are entitlements that cannot be reduced if retention gets too high. Yet occupations

[6] *See Steve Cylke et al., "Estimation of the Personal Discount Rate from Military Reenlistment Decisions," and John T. Warner and Matthew S. Goldberg, "The Determinants of Navy First-Term Retention Behavior in the AVF Era," for some recent empirical evidence on the differential effect of lump-sum bonuses.*

[7] *An alternative to expanded use of reenlistment bonuses is multiple pay tables, wherein each occupation could have a separate pay table and the table could be adjusted as supply and demand conditions dictate. See Martin Binkin and Irene Kyriakopoulos,* Paying the Modern Military, *for a discussion.*



that would benefit the most from higher special pays are already high-bonus occupations. Therefore, any tendency for retention to rise too much in these categories could be offset by reducing bonuses.

The GI Bill

Educational incentives are in-kind benefits that appear to influence recruiting significantly. Congress eliminated the GI Bill, perhaps the most well-known educational benefit, in December 1977 and replaced it with the much less attractive Veterans Educational Assistance Program. Although some politicians and DoD officials predicted that the changeover would have little impact on recruiting, a recent study of enlistment supply by Larry Goldberg estimates that this one program change reduced high-quality accessions by 15 percent between FY 1977 and FY 1980.

This experience with the GI Bill raises a whole set of important policy issues. What is the appropriate mix of first-term pay, enlistment bonuses, and educational incentives? Should we return to the GI Bill? What is the appropriate mix of compensation incentives versus extra recruiting resources? Finding answers to these questions depends crucially on the desired quality mix of accessions and on other considerations such as the spillover benefits of educational expenditures and the benefit of a socially more representative force.

Charles Moskos and other supporters of a return to the GI Bill believe that its elimination and the subsequent emphasis on up-front cash incentives such as higher pay and enlistment bonuses were mistakes. They believe that high mental group personnel are much more responsive to changes in educational incentives than to shifts in active-duty pay. The argument favoring a return to the GI Bill implicitly assumes that the services lack high-quality accessions and that the GI Bill is the only mechanism, short of a return to the draft, that will induce such individuals to enlist. GI Bill supporters also stress its benefits to society in general—a socially more representative force (a high proportion of upper mental group accessions are white) and greater human capital formation. Recent recruiting experience does indicate a need to temper these arguments somewhat; yet, as the economy improves, the problem of shortages of high quality recruits will no doubt reappear.

Most economists view the GI Bill as an expensive enlistment incentive and argue that the same accession mix, or an equally effective alternative, can be had at less cost by using other policy tools. Whereas GI Bill entitlements accrue to all enlistees, the recruiting tools favored by economists (enlistment bonuses, for example) can be targeted to occupations in which shortages exist. Moreover, young people discount prospective GI Bill benefits so highly, according to economists, that smaller up-front cash benefits offer the same enlistment incentive as do more generous but deferred educational benefits. Another drawback is that the availability of GI Bill benefits actually induces many experienced personnel to leave, including individuals whose initial motives for enlisting were unrelated to those benefits.

At this point, the weight of evidence, at least in terms of cost, is on the side of the economists. Larry Goldberg, in his study of enlistment supply, calculates that a new GI Bill would cost about $2 billion per year, or about $100,000 per additional accession. A marginal accession acquired through enlistment bonuses would cost only about $25,000

native recruiting tools are clearly much cheaper than the GI Bill, their costs would probably rise quickly with more widespread use.

A cogent argument against returning to the GI Bill is that it does not focus resources on the most severe problems. If careerist retention rather than initial accession supply is in fact the major manpower problem, the $2 billion in costs associated with a new GI Bill would be much better spent on careerist compensation items such as reenlistment bonuses. Currently, the services spend less than $1 billion per year on reenlistment bonuses.

Less tangible factors, such as the general social benefits of a GI Bill, may counter cost considerations such as these. Right now, however, we do not know whether these spillover benefits are sufficient to outweigh the cost difference between the GI Bill and other, less costly recruiting incentives.

Retirement benefits

The military retirement system, which offers an immediate, lifetime annuity to those who complete 20 years of service, is the focal point of the total compensation system. It shapes the whole pattern of career retention rates, which start out low for younger personnel, rise to almost 100 percent among mid-length careerists, and then fall very sharply among those eligible for retirement benefits. The actuarial cost of the system—the amount that must be set aside yearly to fund accruing retirement liabilities—is nearly 40 percent of outlays for basic pay.

On the surface, the retirement system appears grossly inefficient. Because young people discount future dollars so highly, the current system offers them less incentive to remain in the service than would a system with lower retirement benefits and more active-duty pay. It also provides very little retention incentive for those who complete 20 years of service, as the very low retention rates beyond that point indicate. Many analysts believe that restructuring the retirement system to increase retention among both younger and older personnel (but at the expense of lower retention among mid-length careerists) would provide a force as capable as today's at a significantly lower cost. The retirement proposal advanced by the President's after reviewing the commission's proposal would have precisely such an effect on career retention patterns and force profiles.[8] In fact, estimated accrual costs for these plans are more than 25 percent lower than those for the current system.

Though restructuring the retirement system may seem attractive, caution is in order for several reasons:

- Since most current active-duty personnel would probably be covered by a grandfather clause, any savings achieved under a new system would not be realized for 20 years. Indeed, the two proposals just discussed would add over $1 billion per year to near-term outlays.
- While the current system at least buys a very stable mid-length career force, reallocating retirement resources to active-duty pay would expose even more of the total compensation package to political forces and thus make the compensation base needed to sustain an adequate career force more vulnerable.
- We do not yet know which mix of current and deferred benefits will most enhance productivity. Because retirement benefits are deferred and because continued good job performance is required to become eligible for retirement, the existing system may in fact provide a stronger inducement to productivity than would a system with more up-front compensation.

Congress has already enacted several piecemeal changes to the retirement system that may result in substantial long-term savings. These recent revisions include basing benefits on an individual's high-three-year average basic pay rather than on terminal basic pay and indexing benefits at only half the inflation rate until age 62. While not altering the basic structure of the retirement system, such modifications reduce the fraction of total compensation going to retirement benefits, and the attendant savings allow some increases to active-duty pay. It remains to be seen whether these increases materialize or whether the fears of those warning against any change to the current system prove true instead.

By concentrating on the differences in thinking

[8] *See John T. Warner, "Alternative Military Retirement Systems," for a discussion of these plans and an estimate of their effect on retention patterns.*

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among economists and other defense planners, I am not suggesting that alternative ways of viewing compensation have hindered the development of an effective policy. Rather, I offer this approach as an overview of the difficulties involved in formulating effective military compensation policy. Foremost among problems with the current system is that too much of the total military compensation package is in the form of entitlements, which deny policymakers the flexibility needed to adjust pay to meet manpower requirements. Entitlements do little to help the services overcome shortfalls in specific billets or occupations. Efficiency in meeting these objectives would be better served by allocating a larger portion of the total compensation package to the discretionary items. DMJ

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Hazardous waste management initiatives in DoD

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DoD's aggressive hazardous waste management policy is producing a cleaner, safer environment and conserving resources as well.

For years, the United States and other industrialized nations treated industrial wastes in a rather casual, routine manner. This approach led to numerous environmental problems, some of which—Love Canal in New York, for example, and the Valley of Drums in Kentucky—seriously threatened public health and safety. To correct these problems and to prevent similar situations from recurring, federal, state, and local governments have imposed strict controls on the cleanup, handling, transport, and disposal of hazardous wastes. The Department of Defense is keenly aware of its responsibilities in this area and has inaugurated major programs, preventive as well as corrective, to deal with the hazards posed by industrial waste.

Guiding DoD efforts is a comprehensive hazardous waste management policy. As explained below, to implement that policy, the department has set up an installation restoration program which encompasses identification, control, and cleanup of inactive or abandoned disposal sites and has established several other programs to manage hazardous waste from current and future operations. Research and development initiatives are under way as well.

The magnitude of the problem is great. In 1981, for example, DoD accounted for approximately 92,000 of the 57 million metric tons of hazardous wastes that the United States generated that year.[1] DoD wastes are by-products of its operations and manufacturing processes, especially the manufacture of explosives and propellants, and of the high technology required for specialized military applications.

Most DoD waste streams are like those produced in the civilian sector because the processes or operations involved are similar. Industrial operations common to both include metal finishing, degreasing, painting and stripping, aircraft repair, fuel storage and supply, and pest control. Among the hazardous by-products of such activities are acids, heavy metals, caustics, solvents, paint strippers and thinners, resin, beryllium, fluorescent dye, waste pesticides, and various kinds of sediment and sludge.

In addition, each year the Defense Department purchases more than 50,000 hazardous material line items such as paint removers, pesticides, adhesives, fuels, propellants, and industrial solvents. Both the Resource Conservation and Recovery Act of 1976 and the Toxic Substances Control Act of 1976 mandate a cradle-to-grave chemical waste management program for these substances. DoD has such a program.

Policy

DoD policy on hazardous wastes is to comply with all applicable federal and state laws and with the more than 3 000 local laws, regulations, and standards. The major

[1] *General Accounting Office*, Hazardous Waste Facilities with Interim Status may be Endangering Public Health and the Environment (Washington, DC: Government Printing Office,

Figure 1. Significant DoD policies regarding hazardous waste management

DoD Instruction 6050.5, "Hazardous material information system," January 25, 1978	Establishes a DoD hazardous material data bank to assist personnel in developing procedures to prevent mishaps in the handling, storage, use, transportation, and disposal of hazardous materials; assessing the hazard of materials encountered in DoD work places; and developing environmentally acceptable disposal practices.
DoD Memorandum (Interim guidance), "Oil recycling and reuse policy," June 4, 1979.	Provides guidance on reclamation, recycling, and sale or procurement of lubricating oils, both crankcase and industrial.
Defense Environmental Quality Program Policy Memorandum (DEQPPM) No. 80-5, "DoD hazardous material disposal," May 13, 1980	Issues policy and implementation guidance to the military departments and the Defense Logistics Agency concerning environmentally acceptable hazardous materials disposal procedures.
DEQPPM No. 80-7, "DoD hazardous and solid waste management committee," May 13, 1980	Expands the scope of the committee's responsibilities by including the coordination of the DoD program for managing and disposing of hazardous waste.
DEQPPM No. 80-8, "RCRA hazardous waste management regulations," October 21, 1980	Directs the services and DLA to implement such regulations under the Resource Conservation and Recovery Act; requires, wherever feasible, reducing, reusing, reclaiming, or recycling hazardous waste generated; invests responsibility for local RCRA compliance with installation commander.
DEQPPM No. 80-9, "DoD management of polychlorinated biphenyls (PCBs) and PCB items," November 10, 1980	Directs all DoD departments and agencies to comply fully with Environmental Protection Agency regulations for the handling, storage, marking, and disposal of PCBs and PCB items
DEQPPM No. 81-3, "DoD hazardous material disposal," June 15, 1981	Issues DoD policy on spill residue cleanup and conforming storage.
DoD Directive 6050.8, "Storage and disposal of non-DoD-owned hazardous or toxic materials on DoD installations," August 24, 1981	Limits the use of DoD installations for the storage or disposal of non-DoD-owned toxic or hazardous materials.
DEQPPM No. 81-5, "DoD Installation Restoration Program," December 11, 1981	Issues policy for identifying and fully evaluating suspected problems associated with past hazardous material disposal sites on DoD facilities, controlling the migration of hazardous contamination from such facilities, and controlling hazards to health or welfare that resulted from those past operations.

noted above, is the Comprehensive Environmental Response, Compensation, and Liability Act. DoD, like other federal agencies, also complies with the environmental requirements outlined in Executive Order 12088 of October 13, 1978.[2]

The Office of the Secretary of Defense develops policy and monitors the Army, Navy, Air Force, and defense agencies' environmental programs. Of necessity, however, installations have fundamental responsibility for managing hazardous waste. Installations are most knowledgeable about the many site-specific factors to be considered and most familiar with the multitude of state and local regulations.

On October 21, 1980, the Defense Department established the following waste management objectives:[3]

- To limit the generation of hazardous waste by carefully selecting raw materials and by using operational procedures that are environmentally attractive yet fiscally competitive.
- To reutilize, reclaim, or recycle resources where practical and thus conserve total raw materials used.
- To assure that all options for reuse and recovery are thoroughly explored before discarding material.
- To dispose of hazardous waste in an environmentally acceptable manner.
- To implement within DoD the hazardous waste management regulations that the Environmental Protection Agency published under subtitle C of the Resource Conservation and Recovery Act or those regulations that states enact under EPA authorization.
- To consider all unused hazardous materials as not regulated under the Resource Conservation and Recovery Act until a decision is made to discard them.
- To ensure that all used hazardous materials are safely handled, accounted for, and controlled by inter-

[2] *"Federal Compliance with Pollution Control Standard," Presidential Documents*, Federal Register, *vol. 43, no. 201, October 17, 1978, pp. 47707-47709.*

[3] *Defense Environmental Quality Program Policy Memorandum, Octo er 2 , 1980, subject: R A Hazardous Was e*

EPA has set forth similar objectives,[4] and both agencies emphasize that hazardous waste management begins before waste is actually produced, that is, by reducing the volume of waste generated in the first place. Only then should managers turn to in-process alternatives—recycling and reuse, segregation and concentration, material exchange, treatment, and destruction—and, as a last resort, disposal. Figure 1 summarizes significant DoD policy statements on hazardous waste management.

The secretary of defense also has responsibility, as delegated by the president, for managing releases from DoD facilities and vessels.[5] That responsibility includes:

- Response action, that is, removal and remedial action.
- Investigation, monitoring, survey, and testing.
- Such planning, legal, fiscal, economic, engineering, architectural, and other studies or investigations as are necessary for response actions, cost recovery, and enforcement of the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act.

The secretary of defense has assigned these duties to the secretaries of the Army, Navy, and Air Force, who coordinate DoD's program closely with both EPA headquarters and regional personnel of the Environmental Protection Agency. Regional EPA personnel join DoD program managers in periodic visits to and inspections of DoD facilities and are kept informed about progress at individual installations.

Installation restoration program

A major vehicle for implementing DoD's hazardous waste management policy is its installation restoration program. On November 20, 1981, the assistant secretary of defense (manpower, reserve affairs and logistics) formally designated that program as DoD's "Superfund" program. Its objectives are as follows:

- To identify and evaluate past hazardous material disposal sites on DoD facilities and to control contamination migration that presents a hazard to health or welfare.
- To review and decontaminate, as necessary, land and facilities excess to DoD's mission.

In defense environmental quality program policy memorandum number 81-5, dated December 11, 1981, DoD dictated that the military departments and the Defense Logistics Agency establish and operate their own installation restoration programs.

DoD's installation restoration program for inactive or abandoned sites actually began in 1975, 5 years before passage of the Comprehensive Environmental Response, Compensation, and Liability Act (commonly known as the "Superfund"), which required that EPA be notified of all known or suspected closed hazardous waste sites by June 1981. Of the 274 DoD installations reported to EPA under this provision of the act, 227, or 82 percent, were already participating in the installation restoration program. Since then, DoD has confirmed that almost all reported sites not previously included in the installation restoration program do not require any follow-on action.

In the case of installations that have active disposal sites, the department's goal is to identify by October 1985 all hazardous material sites that may require corrective action. The deputy assistant secretary of defense for installations is monitoring the progress of the military departments toward this goal. As of April 1, 1983, the departments had completed 194 of the 404 records searches necessary to identify those sites. They expect to finish the searches, which cost approximately $50,000 each, by September 1985. To date, remedial actions have been begun at ten installations (see box on p. 34).

Probably the most widely publicized of these ten projects is the Army's effort at Rocky Mountain Arsenal, Colorado. The arsenal is adjacent to the city of Denver, and Stapleton International Airport lies directly to the south. The arsenal complex itself takes in some 17,000 acres. Production of military chemical warfare agents and manufacture of commercial pesticides by Shell Chemical, which began in the 1940s, eventually contaminated the arsenal's groundwater.

Following discovery of contamination in the mid-1970s, data collection and analysis at the arsenal have been extensive. The Army has drilled more than 1,500 wells on the 25-square-mile site and completes as many as 6,000 analyses every month. It has in excess of 270,000 data points on record and has published some 900 technical reports. The Army's effort at Rocky Mountain Arsenal demonstrates the Defense Department's determination to pursue aggressively the cleanup of old waste sites.

Research and development

The Army is the lead service for compiling, refining, and coordinating development of new and improved

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[4] *Environmental Protection Agency,* Hazardous Waste Information, *publication no. SW-737 (Washington, DC: Government Printing Office, 1980).*

Remedial measures at ten military installations*

Anniston Army Depot, Alabama. Anniston Army Depot's mission is to receive, store, maintain, and disseminate general supplies, ammunition, and guided missiles; it is also a tank rebuilding facility. Four areas at the depot cause concern: the industrial area, the metal refinishing facility, and two waste disposal sites. The Army has already detected contamination of groundwater by volatile organic compounds. Remedial action includes a $5.4 million project to remove hazardous materials from the waste disposal sites and a survey to define the nature and extent of groundwater contamination on post.

Rocky Mountain Arsenal, Colorado. The Army established Rocky Mountain Arsenal in 1942 to produce chemical and incendiary munitions and, beginning in 1946, leased portions of the arsenal to private industry for pesticide and herbicide manufacturing operations. In 1974 and 1975, the service detected pesticide by-products in surface water and contaminants in groundwater. A study of groundwater contamination at the arsenal in 1976 indicated that contamination had begun to migrate beyond installation boundaries. To date, the Army has spent $45 million for studies, investigations, and remedial actions. A recently completed containment control study outlined long-range pollution containment and abatement actions costing an estimated $117 million.

Savanna Army Depot, Illinois. Set up in 1918, Savanna Army Depot proofs and tests field artillery weapons and ammunition. A 1982 survey of the depot by the U.S. Army Toxic and Hazardous Materials Agency showed groundwater contamination by chemicals used in explosives. A study to define fully the extent of contamination is in progress and scheduled for completion later this year. The Army has spent approximately $600,000 for studies at Savanna Army Depot.

Milan Army Ammunition Plant, Tennessee. According to a 1980 survey, chemicals used in explosives have contaminated groundwater at the Milan Army Munition Plant, and the Army implemented interim source control measures there in 1981. Thus far, contamination detected off-post is not considered a significant health problem. The Army has undertaken a study to define the nature and extent of contamination and plans follow-on source control measures. So far, expenditures for studies and remedial actions at the plant total $600,000.

Naval Air Station, Jacksonville, Florida. The Navy has completed two cleanup actions, at a cost of $300,000, at its Jacksonville air station. One involved construction of shallow trenches to intercept and treat leachate from an abandoned solvent and petroleum waste pit. The other involved removal and disposal of approximately 300 drums of polychlorinated biphenyl (PCB)-contaminated soil from an area formerly used to store transformers.

Naval Base, Naval Shipyard, Charleston, South Carolina. The naval shipyard at Charleston built a small catchment area in order to intercept and remove small amounts of oil leaching from an abandoned oil sludge pit. Local forces constructed the catchment at minimal cost.

Naval Weapons Industrial Reserve Plant, McGregor, Texas. The Navy plans two cleanup actions, which will cost approximately $200,000, at this plant. One involves a 2-acre area, the surface of which was contaminated with pesticides prior to Navy ownership of the property. The Navy will remove the pesticide-contaminated soil and dispose of it at an approved site. It will also either remove or properly cover asbestos on the surface of the ground at another site; efforts are under way to determine which method of disposal is better.

Pearl Harbor Naval Complex, Naval Shipyard, Pearl Harbor, Hawaii. Excavation for a new building at the naval shipyard in July 1981 revealed contaminated soil from an old chromic acid spill. The Navy removed approximately 2,200 cubic yards of contaminated soil, leached the contamination from the soil, treated the leachate, and placed the cleansed soil in a landfill. Total cost was $175,000.

Wurtsmith Air Force Base, Michigan. Air Force personnel discovered solvent contamination, primarily trichloroethylene, in the base drinking water supply and traced it to a small leak from an underground storage tank. The Air Force has spent approximately $2 million to investigate the problem and to install a treatment system to remove the contamination. It subsequently found other, smaller areas of contamination and will monitor, contain, and treat these areas as well.

Air Force Plant 44, Tucson, Arizona. The Air Force recently detected trichloroethylene and chromium contamination in the groundwater at and near its plant number 44 in Tucson, Arizona, and officials had to shut down several public wells, as well as some at the plant, as a result. Contamination occurred even though past solvent and industrial disposal actions were in consonance with then-prevailing environmental regulations. Some contamination control wells and treatment systems are already operating, and ongoing discussions with city, state, and federal agencies will define final abatement requirements.

**Source: Department of Defense Environmental Policy Directorate,* Information Papers on Department of Defense Installation Restoration Program, *Washington, DC, 1983.*

three interagency agreements now in effect, the Army and EPA are doing research and development on better hazardous waste management methods. The Air Force and EPA have recently completed a related agreement. In entering into these agreements, the Defense Department and the Environmental Protection Agency seek to ensure that the two agencies cooperate and coordinate in carrying out research and development on pollution abatement and environmental quality management.

DoD and EPA are doing research in the following three areas:

Decontamination and cleanup technology. The purpose of this effort is to identify and develop cost-effective, environmentally safe technology for hazard containment and for soil, groundwater, and facility decontamination. Specific projects include pilot testing of rotary kiln incineration for disposing of waste lagoon sediments, studies of the effectiveness of barrier and liner materials for containing hazardous materials, basic research on encapsulation and fixation techniques for isolating materials, and evaluation of techniques for removing contaminants from groundwater and lagoon wastewater.

Also being investigated are nondestructive methods for cleaning up buildings and facilities contaminated with explosives, organics, and heavy metals. The containment and decontamination system currently in place at the north boundary of Rocky Mountain Arsenal was an outgrowth of this research and development program. The system successfully prevents contaminated groundwater from migrating across the boundary.

The Defense Department is searching for innovative as well as conventional methods to solve hazardous waste decontamination problems. Ever-increasing costs for incineration and secure landfills provide the greatest incentive to seek more cost-effective treatment and disposal technologies. Thus DoD supported the first major project for ocean incineration of toxic chemical wastes, and DoD is looking into molten salt combustion, composting, deepwell disposal, and soil incorporation (land farming) as well.

A cooperative project being planned at the Louisiana Army Ammunition Plant near Shreveport will demonstrate closure technology for industrial waste lagoons. Officials expect to complete closure of the first waste lagoon in fiscal year 1984, using solidification of lagoon sludges and in-place burial. Still under study is technology for closure of a second lagoon, which contains chemicals from the manufacture of explosives.

Criteria development. This research includes studies of the environmental effect of contaminants found at DoD installations but not typically found in the civil criteria for gauging the decontamination and health hazard potential of various compounds. More than 20 compounds and their decomposition products have been studied so far. Current research efforts focus on dioxin, hydrazines, urea, picrates, and picramates; the latter two compounds were found contaminating the soil at a naval installation.

Analytical systems. Early in the installation restoration program, DoD identified a need for standardized analytical methods and reference materials in order to promote consistency and reliability across sample analyses performed by various government and contractor laboratories. More than 200 analytical procedures and some 60 standard analytical reference materials traceable to the National Bureau of Standards have been developed for the installation restoration program. These procedures and methods provide a basis for the restoration program's quality control procedures.

Current and future operations

The Defense Property Disposal Service, an activity of the Defense Logistics Agency, is responsible for storing and disposing all hazardous materials turned in by the Army, Navy, and Air Force. Since mid-1980, it has also had central responsibility for assuring that DoD disposes of hazardous wastes in accordance with federal, state, and local laws and regulations. Defense Property Disposal Offices, located on military installations throughout the world, number 137; an additional 74 branches off-installation serve as collection, storage, and transfer points.

Certain wastes, however, remain the responsibility of the individual services, primarily because the military has long had established effective handling procedures for such materials. Among them are:

- By-products from the disposal of toxicological, radiological, and lethal chemical warfare materials.
- Materials that cannot be disposed of in their present form due to military regulations, for example, consecrated religious items and cryptographic material.
- Municipal garbage, trash, and refuse.
- Contractor-generated materials, which are the contractor's responsibility.
- Sludge from municipal and industrial wastewater treatment plants.
- Mining, dredging, and construction refuse.
- Unique wastes and residues from research and development operations.

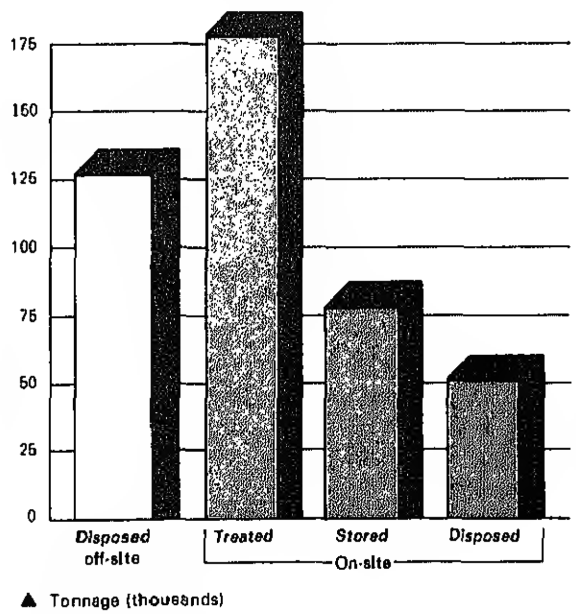
These materials are disposed of either on-site or by contract agents, again in conformance with applicable federal, state, and local laws and regulations.

Defense Property Disposal Service assumes disposal responsibility after the generating activity turns in the material in a properly identified, safe-to-handle container. The service has implemented its disposal program as part of its normal cycle of activities for disposing of excess, surplus, and waste items. Only after offering such items first to other DoD components and then to other eligible organizations and individuals is a contract let for disposal.

These procedures accord with DoD policy, which requires that the hazardous materials disposal cycle include an evaluation of salvage and resale possibilities. Exploring those opportunities often yields results. Recently, for instance, the Defense Logistics Agency sold 368 tons of phosgene, manufactured as a chemical warfare agent by the Army during World War I, to a civilian firm in New York state. The firm used the chemical (carbonyl chloride) as a feedstock in manufacturing urethane plastic.

Other reprocessing options can also be effective. Recently completed studies have shown that bases using only a few drums of solvent per year can economically recycle them by means of commercially available stills. DoD is therefore developing a comprehensive program for waste solvent segregation, collection, distillation,

Figure 2. Handling of hazardous waste generated by 300 DoD installations in 1981



Source: MBO Reports, DoD Environmental Policy Directorate, 1982.

solvents; only unrecyclable wastes, such as still bottoms, will be discarded. The department is also investigating re-refining of waste lubricating oil at regional centers for recycle to DoD users.

When resale or recycling is not possible, disposal is the only alternative. Though DoD has many of its own storage, treatment, and disposal facilities, it relies primarily on civilian contract firms to treat or ultimately dispose of hazardous waste. In 1981, for instance, the department disposed of 51,000 tons on its own sites and 127,000 tons off-installation (see Figure 2).

Because outside firms are so critical to DoD's disposal program, the department shares the national concern over projected shortages of certain types of hazardous waste treatment, storage, and disposal facilities.[6] The United States will need about 50 to 60 new hazardous waste management sites over the next several years.[7] Compounding the problem are the hundreds of old, environmentally inadequate disposal sites scheduled for remedial action that will require removal and relocation of wastes. Other existing facilities will have to close as strict regulations enacted under the Resource Conservation and Recovery Act go into effect or as the facilities themselves reach capacity.

Unfortunately, many recent attempts to locate sites for new facilities have not been successful due to opposition from local residents. In fact, few U.S. localities have allowed construction of new off-site hazardous waste treatment or disposal facilities since 1978.[8] To resolve the impasse, officials may have to consider interstate agreements for hazardous waste management similar to those being developed for low-level radioactive waste under the Low-level Radioactive Waste Policy Act of 1980.[9]

Technological innovation may also help alleviate the disposal problem, and the Army, Navy, and Air Force are all working on new technology to manage hazardous wastes more effectively. Research is in progress in the

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[6] *Environmental Protection Agency,* Hazardous Waste Generation and Commercial Hazardous Waste Management Capacity: An Assessment, *publication no. SW-984 (Washington, DC: Government Printing Office, 1980).*

[7] *U.S. Congress, Senate Report no. 848, 96th Congress, 2d Session, 1980.*

[8] *"Siting of Hazardous Waste Management Facilities: A Major Problem Facing Industry and States,"* Environment Reporter, *November 13, 1981; General Accounting Office,* How to Dispose of Hazardous Waste—A Serious Question That Needs to be Resolved, *II (Washington, DC: Government Printing Office, 1978).*

[9] *K. L. Florini, "Issues of Federalism in Hazardous Waste Control: Cooperation or Confusion?"* The Harvard Environmental Law Review, *vol. 6, no. 2, 1982, pp. 334-336.*

following areas: control of wastewater and air emissions from munitions plants and depots, environmentally safe disposal techniques for obsolete or excess munitions, recovery and reuse of explosives and propellants, and computer-aided systems for managing hazardous materials. The Army has already developed a sulfide precipitation method for treating electroplating waste and recently installed a pilot system at Tobyhanna Army Depot.

Other service research programs hold promise as well:

• The Navy and the Department of Energy are jointly testing a closed-loop system for recycling toxic chrome electroplating wastes at the Naval Air Rework Facility in Pensacola, Florida. Using an energy-efficient evaporation process, the system concentrates hazardous waste effluents to a point at which they may be returned to the electroplating process, thereby conserving resources and avoiding generation of hazardous waste. Initial results have been very encouraging, and additional work is under way to apply the concept to other electroplating processes such as cadmium-cyanide.

• The Air Force Engineering and Services Laboratory, located at Tyndall Air Force Base, Florida, is studying packed-tower air stripping as an efficient and economic method for long-term cleanup of trichlorethylene in groundwater. (Trichlorethylene is an organic solvent formerly used by numerous DoD and commercial activities as a degreasing agent.) The process strips volatile impurities from liquids by exposing the contaminated liquid to a turbulent countercurrent air stream, thereby transferring the impurities to the air. Since trichlorethylene concentrations are often very low (less than one part per million), air emissions are not likely to be significant; if they are, carbon absorbers can be added to the system. The process has potentially broad application, and the Air Force is studying the feasibility of air stripping other volatiles as well.

• Another Air Force project may extend the life of paint stripping solutions by reclaiming the solvent. Deterioration in paint stripper performance coincides with the buildup of paint solids, but the Air Force Engineering and Service Center has developed techniques that remove paint solids from the stripping solution and yield a recovered product that meets performance specifications. A full-scale, precoat, pressure filtration system now being evaluated at Hill Air Force Base, Utah, will save $50,000 for every month the life of the paint stripper is extended.

Even new waste management techniques such as these will not eliminate disposal problems, but they will significantly reduce the amount of hazardous waste produced. Controlling the total volume of waste generated can in turn lessen the hazard in many military operations and should be an integral part of all hazardous waste management programs. Base and technical support personnel should examine installation activities to determine feasible source reduction options and reuse incentives.

In addition, high hazardous waste disposal costs require a new emphasis in military procurement, manufacturing, maintenance, and refurbishing operations. Economic analyses that include only research and development, acquisition, and operating and maintenance costs do not go far enough; the projected costs and benefits of hazardous waste management are important factors as well. Safe handling and disposal of hazardous material directly affects system costs, as does any potential for recycling or reuse.

The initiatives described earlier demonstrate that DoD has been sensitive to the problems posed by hazardous waste. Even as it searches for ways to control disposal costs up-front, the department will continue to pursue actively its sound hazardous waste management policy and program. Reduction of hazardous waste at the source, as well as more advanced but less expensive control technology, will remain Defense Department goals for the foreseeable future. DMJ

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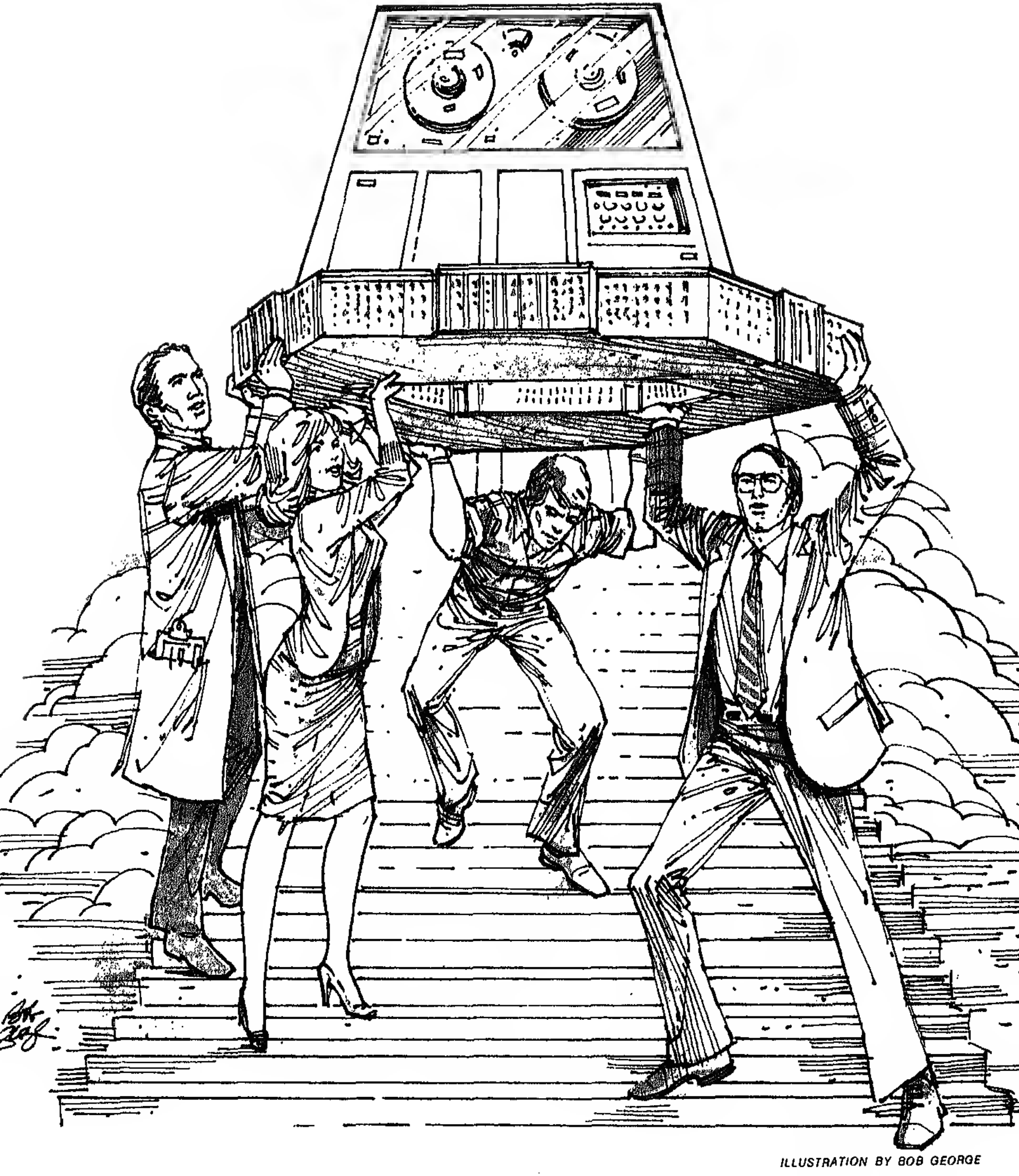

ILLUSTRATION BY BOB GEORGE

Civilian personnel management and advancing technology

By LAURIE A. BROEDLING

The massive upgrading of the defense support establishment now in progress will fully succeed only if DoD updates outmoded personnel practices as well.

The Department of Defense support establishment is undergoing a technological revolution. Industrial automation and related manufacturing technologies are bringing this revolution to the shop floor; communication and computing systems are bringing it to DoD offices. By enhancing readiness and lowering costs, this technological revolution could profoundly improve the effectiveness of the defense support establishment. But the full potential of this revolution will go unrealized unless the personnel management system changes to meet the requirements of the new technology. This article addresses the need to modify that system.

The military support establishment is that part of DoD which researches, develops, procures, and maintains weapons systems, supplies, and facilities. DoD employs almost one million civil service personnel, and the vast majority of these work on the support side as opposed to the operational side. Civil servants, therefore, will largely be responsible for operating the new technology, and this article focuses on civilian personnel management and administration. However, the issues discussed are equally relevant to the uniformed officers who constitute much of the senior line management for the defense support establishment.

The defense industrial support establishment last underwent a period of major change in the 1940s. During World War II it increased drastically in size almost overnight, and, to the extent feasible, the military obtained state-of-the-art technology to produce and maintain weapons systems. In tandem with major technological innovation went changes in the civil service personnel system. In 1941, for example, the Congress within-grade increases based on seniority and merit. Shortly after World War II, it passed the Classification Act of 1949 in order to assure equity in treatment and compensation across large numbers of people and occupational categories.

During the next three decades, the complexity, sophistication, and capability of military weapons systems evolved rapidly, but the technology used to develop and especially to maintain this hardware did not keep pace. Even such basics as buildings and transportation received minimal upgrading. In the words of Rear Admiral James Ahern, "If we were to take all of our physical plants in the Navy . . . and if we were to just freeze deterioration and spend the same amount of money we are spending today on real property maintenance, it would take 8 years to restore them to livable, habitable structures. That is how rundown they are."[1]

Until 1978, the civilian personnel management system also changed relatively little. The laws, regulations, and management practices remained much the same as those in place immediately after World War II, and thus modifications to hiring, promotion, discipline, and training practices were few. Even the size and composition of the DoD civilian work force remained fairly stable. Many of the department's civilian managers and supervisors had joined their organizations in the late 1940s and early 1950s and worked their way up through the ranks. Moreover, the predominant organizational

[1] *Rear Admiral James Ahern, USN, in* Military Productivity and Work Motivation: Conference Proceedings, *ed. Laurie A. Broedling and Robert Penn, Special Report 78-15 (San Diego, CA: Navy Personnel Research and Development Center,*

form has continued to be vertical management hierarchy, that is, a functional division of labor within departments, use of chain-of-command procedures, and a flow of communication primarily from top to bottom, with relatively less flowing laterally, and an even smaller amount going from bottom to top.

The Civil Service Reform Act of 1978 marked by far the most profound change to the civil service system in almost a century. But its purpose was to upgrade and modernize management of the federal civil service, not to deal with problems attendant upon the wholesale introduction of new technology. Therefore, its provisions could not and should not be expected to deal with this issue.

The defense support establishment of the late 1970s was a product of the interaction of three elements of a system:

- Military material—weapons systems and supplies.
- Technology—the equipment, processes, and facilities to procure and maintain military material.
- Personnel—the methods for recruiting, managing, and administering the work force that applies the technology to obtain and maintain the military material.

The complexity of military material had advanced rapidly in the preceding thirty years, while the technology element changed modestly and the personnel element changed only slightly. The result was a strain on the overall system which manifested itself in problems with productivity, costs, and suboptimal use of sophisticated weapons systems.

These problems largely derive from relying on the personnel management and administrative methods of a bygone era at a time when DoD must acquire and maintain high-technology weapons systems. In civilian personnel administration, for example, classification and staffing are major problem areas. The perception is that these processes are slow, cumbersome, unresponsive to management needs, and that they create an adversarial relationship between line management and personnel staffs.[2] As a result, managers have a great deal of difficulty filling vacancies and creating new positions.

The need to update all areas of federal personnel management and administration is likely to take on added urgency shortly. For within the last 5 years, military support technology, one of the three elements most critical to the defense support establishment, has begun to undergo major changes. Defense experts have recognized that outmoded technology poses a serious problem, and large-scale efforts are under way to correct it. To appreciate the magnitude of the impact on personnel requires some understanding of the corrective actions in progress.

Principal among these are special investment programs set up to finance the modernization of plants and equipment. Fast-payback capital investment programs, for instance, fund capital improvements which can pay for themselves within a certain time period. By fiscal year 1981, funding for the two major DoD-sponsored investment funds—productivity investment funds and productivity-enhancing incentive funds—was $75.8 million, and it rose to $166.1 million in FY 1982. For FY 1983, the budget is $194.0 million. A related effort, the Defense Department's manufacturing technology program, seeks to advance the state-of-the-art in manufacturing and repairing all types of military equipment. In the current five-year period, DoD invested $745 million in the program, double the investment during the previous five-year period.[3]

Various other initiatives will probably quicken the pace of technological innovation as well:

- On August 19, 1981, the Deputy Secretary of Defense issued a memorandum (subject: financing of equipment purchased for industrial fund activities) which creates a financial method that allows industrially funded activities to depreciate their equipment and charge capital investments to the industrial fund rather than depending on appropriated funds.
- Both the Office of the Secretary of Defense and the services have instituted measures that demonstrate an intent to marry logistics and acquisition considerations in the planning and programming process; in other words, maintenance feasibility and costs will play a large role in the decision to develop or not develop a weapons system.
- Computer equipment costs have been dropping rapidly; in particular, small, "stand-alone" computers have become affordable to managers.
- The overall emphasis within DoD on the need to increase productivity is fostering an organizational climate which encourages and rewards managerial initiatives in this area. The Naval Material Command, for

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[2] *Laurie A. Broedling, Ken S. Crawford, Gary D. Kissler, Deborah A. Mohr, Arthur R. Newman, Michael A. White, Herman Williams, Leanne E. Young, and Thomas J. Koslowski,* An Examination of Productivity Impediments in the Navy Industrial Community, *Special Report 81-2 (San Diego, CA: Navy Personnel Research and Development Center, 1980); Thomas J. Koslowski,* Assessment of Civilian Personnel Management and Equal Employment Opportunity Issues, *Special Report 82-3 (San Diego, CA: Navy Personnel Research and Development Center, 1981).*

[3] *Richard Donnelly, "Department of Defense Presentation," in* Proceedings of the Thirteenth Annual DoD Manufacturing Technology Conference, *San Diego, CA, November 30-December 3, 1981, p. 19.*

example, has established a network of productivity steering committees, and its chief gives an annual award to activities that have demonstrated productivity excellence.

What does this new technology look like? On the industrial side, it means using "smart tools" to automate many functions previously done manually; an extreme form is the fully automated robot. An extraordinary array of functions can be automated. The Yamazaki Machinery Works in Nagoya, Japan, has a new plant that employs 10-12 workers during the day and one at night (the watchman). It produces precision machine components 24 hours a day, 365 days a year, and Yamazaki expects to recoup its $18 million investment in the plant in two years.[4]

Near-term applications of individual automation in the Defense Department include automated warehousing and robotic deriveters. Several automated storage and retrieval systems for supplies and parts are already in place, and more are scheduled. In their most advanced form, these systems use machines to perform the majority of storage and retrieval activity and computers to keep the inventory, direct the equipment and people (in accordance with algorithms for priorities and for optimizing use of both space and time), and keep information on employee performance. Robotic deriveters, now being developed, will use a combination of computers, television cameras, and sensing devices to remove rivets from parts such as aircraft wings without the direct involvement of workers.

Automation is but one of a wide array of industrial technological developments that are radically altering the work place. Nuclear technology, for instance, has made available a mobile neutron radiography system that can inspect aircraft for corrosion and deterioration without disassembly. Also, lasers can now scan bar codes to automatically identify and inventory material, and laser holography can identify and diagnose problems on large surfaces of ships and aircraft.

Another major area of technological change is computer-aided design and manufacturing (CAD/CAM). Computer-aided design enables engineers and draftsmen to do design work on a cathode-ray tube supported by a computer, which can give tolerances, display a design in three dimensions, enlarge details, change shapes, and test, modify, and store designs for future reference. The computer can even subject a design to electronically simulated temperature changes, mechanical stresses, and other conditions. Computer-aided manufacturing links design with the automated machinery that actually makes the product. The impact on engineering productivity is great, especially in reducing the time needed for design and testing. Virtually nonexistent five years ago, the market for computer-aided design and manufacturing is expected to surpass $8 billion by the end of the 1980s.[5] In fact, the Navy Laboratories Interactive Graphics Program recently granted a contract for $63 million worth of such equipment—as many as 33 systems and 295 work stations—to be introduced into six Naval Material Command research and development centers over the next 8 years.

The impending technological changes in the office are no less dramatic. Basic office technology has changed little in the last one hundred years; paper and pencils have been the principal tools. Suddenly, however, managers, professionals, and clerical personnel all find themselves becoming part of a network of communication and computation equipment. Electronic transmittal of most routine business mail is likely to be the norm, and paperless offices are already technologically feasible. In sum, the office of the immediate future will become increasingly unrecognizable in terms of our recent frame of reference.

The steps now being taken toward massive technological upgrading of the defense support establishment are long overdue. Unfortunately, they represent only half the solution, for reasons perhaps best explained by way of an organizational model called socio-technical systems theory. This theory holds that organizations are systems comprised of two major, inextricably linked subsystems, personnel and technology. Attempts to change one subsystem without changing the other will fail; either the first subsystem will revert to its original form or there will be unintended, negative consequences in the second.

The classic demonstration of the theory's validity comes from a study done by London's Tavistock Institute, which first formulated socio-technical systems theory in the early 1950s.[6] In Great Britain prior to World War II, coal was mined by teams of six workers, two to a shift, who were paid on the basis of the team's total output. In the interests of significantly greater productivity, management replaced this method with a new, mechanized technology called the long-wall method. It substituted division of labor for groups doing the entire mining job and put more distance between workers along a much longer coal seam.

Unfortunately, productivity did not improve under

[5] *"Now the Star Wars Factory,"* Time, *November 2, 1981, pp. 74-81.*

[6] *E. Trist and K. Bamforth, "Some Social and Psychological Consequences of the Long Wall Method of Coal-getting,"*

the long-wall method because management had not considered its effects on the personnel system. Coal mining is difficult, dirty, dangerous work. The team approach to the job had evolved to provide the mutual trust and support that miners needed. Physically spacing workers out in a line completely eliminated this source of support. Moreover, the men preferred doing the whole job to being highly specialized. As a result, absenteeism rose and productivity fell under the new approach. However, the Tavistock study team was able to develop a composite system which retained the social benefits of the old system but permitted introduction of greater mechanization as well. The lesson learned was that social and technical subsystems must be in consonance, and the literature in organizational research abounds with findings which corroborate this point.

The implications for DoD are clear. The technological advances described earlier, now being rapidly introduced into the defense support establishment, will not have the desired effect unless personnel management methods are adjusted accordingly. These very expensive capital investments will not return maximum gains if the employees who operate and maintain the equipment are improperly selected, trained, compensated, motivated, evaluated, and given direction. If any of these conditions hold, the consequences for organizational productivity (the ability to meet production schedules and quality at reasonable cost) and employee attitudes will be negative. Adjusting personnel management practices to accommodate the new technology is, like the technology itself, complex and challenging. Yet, while no one approach suits all circumstances, some generalizations do pertain.

Certainly personnel managers will be dealing with new kinds of jobs. Not only is the new technology creating jobs that did not exist before, it is changing the distribution of types of jobs as well. Thanks largely to industrial automation, for example, the number of blue-collar workers is declining, while the number of white-collar workers continues to rise. Moreover, the nature of both kinds of jobs is changing. Most workers will be interacting much more with computers and computer-driven, automated equipment. Whether this change will require higher skills (to operate such sophisticated technology) or lower skills (because the computer does most of the "thinking") is an important question.

Changes in the nature and distribution of jobs have major implications for selection, classification, compensation, training, and retraining. Different jobs require different skills and skill mixes; therefore, personnel managers will have to recruit new types of employees and arrange transfers and retraining for existing employees. What does a manager do with "excess" employees after a labor-saving device is introduced? DoD does not have a system-wide mechanism for capturing such savings in ceiling points. Generally, organizations will go to great lengths to avoid reductions-in-force, but such efforts do not always redistribute labor as efficiently as possible.

Classification and compensation methods must also keep pace with new job requirements and skill mixes. The specific issues in this area are numerous and diverse. Chief among them is the need for new job series and new standards as the rate of technological change begins to accelerate. Under existing classification procedures, creating even one new job series through the Office of Personnel Management takes several years. The computer specialist series, for example, did not come into official existence until long after thousands of computer specialists were already functioning in the federal government. Forcing people into inappropriate job series for the work to be done leads to inequities and to dissension within the work force.[7]

Compensation is a related issue. If higher skills are needed to operate increasingly sophisticated technology, then wages must be commensurate and will mitigate some of the savings that derive from greater productivity. Conversely, if lower skills are needed (because computer brainpower reduces the need for human brainpower), then wages can be decreased without detracting from productivity. However, management then faces the problems associated with downgrading jobs. It runs other risks as well. If for some reason these lower-skilled workers do not operate the equipment adequately at first, management may have to contend with the public embarrassment of seeming to have invested a lot of money to little avail.

High technology also has implications for the way in which organizations are managed. For example, though fewer in number, the blue-collar workers remaining will be very important; they will be responsible for properly operating and maintaining a sophisticated and expensive industrial plant. The maintenance function will be particularly important. With most workers directly tied, on-line, to CRTs and other automated equipment, work will stop when the computer goes

[7] *One innovative approach to avoiding some of the rigidities of the federal job classification system is the Navy demonstration project being carried out at the Naval Ocean Systems Center at San Diego and the Naval Weapons Center at China Lake, California. Conducted under the authority of the Civil Service Reform Act, the demonstration system replaces existing general schedule grades and the fine distinctions they require with broad pay bands within general classification levels.*

down. At the minimum, a shutdown can be very frustrating; at the maximum, it can be very expensive.

In addition, the continued shift toward a white-collar work force will mean less people doing work for which the output is easily quantifiable. More people will be performing jobs that require self-direction and a capacity for independent judgment and quick thinking. For instance, someone responsible for monitoring the functioning of a large set of interconnected machinery must be able to act immediately when the equipment malfunctions. If he or she feels compelled to check first with a supervisor (who is likely to be physically distant under the configuration of new plants), the delay could mean severe damage or, at least, a large loss of time. Because new industrial plants are highly interconnected, the failure of one part will affect others as well. An employee's willingness to make decisions and act independently will be an asset under these conditions.

Suffice it to say that such jobs and employees require innovative approaches to encouraging motivation and productivity. The roles and styles of supervisors and managers will have to change. For example, managers will have to concentrate on developing "bottom-up" communication patterns with employees, patterns which recognize the valuable expertise that subordinates possess. At the same time, ironically, most employees will be tied to a computer, giving management the power to monitor their actions and performance literally by the second in some instances. Misuse of this capacity for surveillance could seriously discourage risk-taking on the part of employees.

The different communication patterns and methods of decision-making that are evolving will also require modified organizational structures to support them. Office automation, for example, is making much more information quickly accessible to managers. While easy access to large quantities of information may improve managerial decision-making, it also has the potential to degrade the process, since information overload may prove confusing and burdensome.

Similarly, paperless offices are feasible but may or may not prove desirable. It is more tempting to remove permanently a piece of aversive, but perhaps important, information from a CRT screen than from an individual's hands. Moreover, office technology could in fact drastically increase the amount of paper rather than reduce it. Networks of automated word processors and high speed printers will make it technologically feasible for managers to drown themselves and their subordinates in paper at the press of a button.

The amount of direct personal interaction in offices will also probably drop. Workers will interact primarily through terminals, work stations, and video-conferencing, and increasing numbers of people will work off-site. The possible effects on decision-making are far-reaching. For instance, most proposals to establish or change policy now circulate sequentially, and the sequence is usually hierarchical (the "chop chain"). Office automation could speed up that process, which is usually very slow, by disseminating or requesting information simultaneously rather than sequentially. Whether such a change would represent an improvement in the decision process is a matter which warrants consideration in advance. Technological change could profoundly alter traditional organizational structure as well. As the computer makes available more clerical services, the size of support staffs should decline correspondingly, and organizations should evolve from the

A brave new world—the office of the future

John Diebold, Chairman of the Diebold Group, Incorporated, and a pioneer in office automation, anticipates the following scenarios:*

Automated office systems for executives. These will keep track of schedules, dates, and deadlines, as well as personal reminders and notes. They will maintain files and provide research capabilities. They will allow the sending and receiving of communication to peers, superiors, and subordinates directly and instantaneously, while in the office, at home, or on trips.

Business offices in the home. Executives are not the only ones who will work more at home. Other workers, including clerical personnel, will be able to perform their functions off-site.

The entrepreneurial work force. People with specialized professional skills, such as accountants or systems analysts, can be highly selective about the work they perform. Many will become consultants or subcontractors to their previous employers. They will perform their functions off the premises of the employer and at their own convenience.

The office communications center. Each individual white-collar work station will become a computer and communications center. Not only will workers be able to perform existing tasks faster, but many new capabilities will be available. People across the country will be able to conduct meetings via video-conferencing. Workers will have new and more direct access to data bases and will be able to do statistical analyses and simulation.

Source: John Diebold, "Increasing Office Productivity through Information Technology," in Productivity: Prospects for Growth, ed. Jerome Rosow (New York: Van Nostrand Reinhold, 1981).

pyramid shape now predominant to a diamond shape.[8] However, if employees do not take full advantage of the computer's clerical capabilities but continue to rely on the traditional clerical staff instead, then organizational structures will not change, nor will productivity gains be fully realized.

DoD managers also need to consider the interaction of new technology with the "new" work force. That part of the federal work force hired shortly after World War II is in the process of retiring, and social analysts maintain that the workers taking their place are different in several fundamental ways. They have a much higher level of education, are more heterogeneous in terms of race and sex, have higher expectations about the extent to which their jobs should provide them with self-fulfillment, and are far less likely to accept authority in an unquestioning manner.[9] While some bemoan certain of these characteristics, like it or not, it is the only work force we have. Moreover, the characteristics may be assets rather than liabilities under conditions of the new technology.

The preceding discussion takes up only a few of the myriad ramifications of introducing a substantially new technology into the defense support establishment. The purpose has not been to describe all implications or to outline all possible outcomes. Rather, by way of example, the intent has been to encourage managers and personnel policymakers to begin actively considering the impending changes. As they do so, several observations are in order.

The importance of flexibility in successfully adapting to change is one. Headquarters should give field activities leeway in organizing and managing to meet the demands of new technology. Even similar field activities are introducing different kinds of technology at different rates and need to be able to modify their organizational subsystems accordingly. If they are to do so, headquarters' management must decentralize more decision-making and put less emphasis on standardization of the organization across similar kinds of field activities.

Also worth noting is the excellent opportunity that new technology often offers for reducing managerial layering and thus improving position management. Computers will allocate and assign much of the work, thereby reducing the need for supervisors and managers. Moreover, employees' direct knowledge of the intricacies of high-technology equipment often puts them in a better position than management to decide how to best use the equipment. Capitalizing on this knowledge, however, will require increased trust of employee capabilities on the part of management.

In implementing the new technology, managers also need to be aware that design of the personnel (that is, social) and technological subsystems should proceed in tandem. Now, unfortunately, if redesign of the personnel subsystem takes place at all, it usually does so after technical design is set, a sequence of events that works to the detriment of smooth and efficient organizational functioning. Securing approval for all personnel actions should precede installation of technology. Personnel administration, of course, should not lag behind technological change. If a new job series or change in existing standards is needed, it should not take years to obtain.

In the last 3 decades, the U.S. military has demonstrated a capability, unparalleled in human history, to develop sophisticated equipment and material. It has recently begun to apply the same capacity for technological innovation in the support establishment. If current initiatives continue, a technological revolution is about to occur. This new technology represents a huge capital investment and is badly needed to enable the civilian work force, which almost certainly will not increase beyond its present size, to acquire and maintain increasingly sophisticated weapons systems. To reap the benefits of technological innovation, however, officials at all levels must begin to develop personnel management regulations and practices consistent with the new technology. If people in the DoD can meet that challenge, our defense capability will undergo a revolution too. DMJ

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[8] *Shoshana Zuboff, "New Worlds of Computer-mediated Work,"* Harvard Business Review, *September-October 1982, pp. 142-152.*

[9] *Rosabeth Moss Kanter and Barry Stein, "Value Change and the Public Work Force: Labor Force Trends, the Salience of Opportunity and Power, and Implications for Public Sector Management," in* Conference Report: The Changing Character of the Public Work Force, *Office of Personnel Management Document 134-59-7, Washington, DC, March 1981, pp. 66-80.*

Event	Date	Place	Contact
Designing Effective Man/Machine Interfaces	Nov 15-18 Dec 6-9 Dec 13-16 Jan 31-Feb 3 Feb 7-10	Washington, DC San Diego, CA Boston, MA Baltimore, MD Palo Alto, CA	Integrated Computer Systems 3304 Pico Boulevard P.O. Box 5339 Santa Monica, CA 90405 (213) 450-2060
Personal Computers for Managers	Nov 29-Dec 1 Jan 24-26 Feb 14-16	Palo Alto, CA San Diego, CA Washington, DC	
A-76: Improving the Efficiency and Effectiveness of Government	Nov 15-18 Dec 5-8 Jan 9-12 Jan 24-27 Feb 27-Mar 1	San Antonio, TX Denver, CO San Diego, CA Honolulu, HI Orlando, FL	U.S. Professional Development Institute 1805 Powder Mill Road Silver Spring, MD 20903 (301) 445-4400
Software Engineering with Ada	Nov 14-17 Dec 5-8 Dec 12-15	Boston, MA Orlando, FL Los Angeles, CA	
Management Skills for Supervisors	Nov 17-18	Annapolis, MD	Center for Management Development
How to Use a Personal Business Computer: Programming in Basic	Nov 28-30	Reston, VA	College of Business and Management University of Maryland College Park, MD 20742 (301) 454-5577
Management Skills for Women Supervisors and Administrative Assistants	Nov 29-30	Timonium, MD	
Modern Management and Supervision	Dec 5-9 Jan 9-13	Washington, DC Washington, DC	Graduate School, USDA 600 Maryland Avenue, S.W. Washington, DC 20024 (202) 447-3247
Increasing Productivity Through Stress Management	Dec 15-16	Washington, DC	
AICPA Auditing Standards—Their Applicability to Government Audits	Dec 12-14 Jan 23-25 Feb 8-10 Feb 13-15	Washington, DC Dallas, TX Washington, DC San Francisco, CA	
Advanced Seminar on Information Management in Public Administration	Feb 6, 13, 21, & 27	Washington, DC	
Eighth Annual Air University Airpower Symposium	Mar 5-7	Montgomery, AL	Airpower Symposium ATTN: Lt. Col. Richard Eyermann Air War College (AWC/EDRP) Maxwell AFB, AL 36112 (205) 293-2831